THE ENGINEER

A Seven-Day Journal

The Budget

The Chancellor of the Exchequer, Mr. Hugh Gaitskell, presented his Budget for the current financial year in the House of Commons on Tuesday afternoon. In the course of his speech he said that total expenditure for the year 1951–52 was estimated at £4,197,000,000, or £939,000,000 more than last year. Defence preparations and essential stockpiling would require about £1,490,000,000. The Chancellor's proposals for finding the additional revenue include an increase of 6d. on each of three rates of income tax, making the new rates 9s. 6d., 5s. 6d. and 3s. in the pound; an increase from 30 per cent to 50 per cent—dating from January 1st last—in the tax on distributed profits, the tax on undistributed profits remaining at its present level of 10 per cent; increase from 33⅓ to 66⅔ per cent in the purchase tax on new motor-cars, wireless and television sets, valves, and on gas or electrically operated domestic appliances, and an increase of 4½d. a gallon in the Customs duty payable on petrol and other light oils and on heavy oils used as road fuel. It is also proposed to suspend all initial tax allowances on industrial buildings and structures, on machinery or plant, and on mines and oil wells in respect of expenditure incurred on or after April 6, 1952. Other changes include increases in some sections of the entertainments tax and the introduction of part-payment for certain dental and optical services under the National Health Scheme. Pension benefits for men over seventy and women over sixty-five are to be increased, and pensioners below those ages are to be permitted to earn £2 a week, instead of £1 as at present. This, the Chancellor said, was to encourage people to remain at work to a later age than was now customary, if they were physically capable of doing so.

Railway Charges

On Monday last, the Minister of Transport, Mr. Barnes, stated in the House of Commons that, as from April 16th, there would be a 10 per cent increase in the railway freight charges, parcel rates and docks and canals charges of the British Transport Commission. The Minister said that he had regarded it as a matter of urgency to authorise the increases immediately, under Section 82 of the Transport Act, in view of the British Transport Commission's present financial position, resulting from recent sharp rises in costs. He had received advice on the matter from the permanent members of the Transport Tribunal, who had estimated that the 10 per cent increase would bring in £20,000,000 in a full year. That amount, however, the Minister observed, would not cover the present total deficiency. The memorandum on the subject prepared for the Minister by the permanent members of the Tribunal explained that, if the increase was authorised immediately, the British Transport Commission's accumulated deficit at the end of 1951 would be of the order of £51,000,000. The Tribunal members thought it to be of the utmost importance that such a deficit should not be allowed to grow pending the coming into operation of a complete charges scheme. Their memorandum emphasised strongly the necessity of securing every possible economy in the operating cost of the Commission, and pointed out that, unless substantial economies could be effected, the financial position of the Commission, on the figures available, would not be stabilised through bringing the present increases into operation. A statement on the matter, issued on Tuesday, by the Federation of British Industries, commented that industry viewed this further increase in railway charges with the gravest concern. The F.B.I. considered that there should be no increase in freight charges until the possibility of absorbing increased costs by operating economies had been really vigorously tackled. Industry was not satisfied that that had yet been done.

Retirement of Mr. C. E. Allen

The retirement has been announced of Mr. Clary Edgar Allen, who has been the Editor of our contemporary *Machinery* for nearly forty years and a director of the Machinery Publishing Company, Ltd., for some twenty-four years. Mr. Allen, who has been a well-known figure in the machine tool industry for so many years, was born in 1871, and after being privately educated studied mechanical engineering at King's College, London, and electrical engineering at the Northampton Polytechnic Institute and Birkbeck College. Following some years of industrial experience he entered technical journalism in 1898, when he became Acting Editor of *Fielden's Magazine*, which later became *The Engineering Review*, with Mr. Allen as Editor and director. Whilst in this office he acted as a consulting engineer for machine shop equipment and power plant, and was closely concerned in the organisation of the Machine Tool Exhibitions held at Manchester in 1910 and in London in 1912. In 1912 Mr. Allen was appointed Editor of *Machinery*, and in 1927 he joined the board of Machinery Publishing Company, Ltd. During his years of office, Mr. Allen has travelled widely and has long been a recognised authority on both British and foreign machine tools and shop equipment. There can be but few connected with the machine tool industry or with technical journalism who do not know and respect Mr. Allen, whose charm and interesting personality have made him a wide circle of friends in his extensive travels. We feel sure that all who know him will join us in wishing Mr. Allen a long life and much happiness in his well-earned retirement.

Canadian Shipping

At the recent annual meeting of the Shipping Federation of Canada, the President, Mr. A. L. Lawes, in his address, said that the position of the remaining part of the Canadian merchant fleet should be under constant supervision of the Government. Although shipping had reverted to its normal commercial function there remained some controls which caused uncertainty and they were reflected in the operation of the ships. Other factors which raised difficult problems for the shipowner were, he maintained, the continuance of bulk purchasing and the disturbance caused by currency controls. Mr. Lawes referred to the prevalence of the fast cargo liner among the new tonnage and the improvement in design which had resulted in the production of highly efficient cargo ships for specific trades. However, he remarked, the advantages of high speed, gained at such high cost, had been nullified by increased port delays, and he emphasised the need for a quick turn-round to offset the steadily mounting operational costs. The President mentioned that deep sea tonnage now available met present trade demands and that the majority of ships in service had been built since the war. He briefly called attention to the improvements in harbour facilities and the need for additional works. Continuing, Mr. Lawes said that the limited availability of currency had restricted purchases with a resultant reduction in cargoes leaving Canadian ports, but that was counterbalanced, to some extent, by an increase in inward freight. Turning to passenger travel, Mr. Lawes reported that it had remained at a high level, but there had been a fall in the number of emigrants, a trend which he expected would be reversed in 1951. Finally, the President was pleased to record the satisfactory labour relationship which had obtained during the year.

The Royal Aeronautical Society

The Royal Aeronautical Society has announced the election, as President for 1951–52, of Major F. B. Halford, C.B.E., who has been a Fellow of the Society since 1927 and has served on the Council since 1949. Major Halford was educated at Felstead School and at Nottingham University, and began his aeronautical career in 1912 as a pilot instructor at the Bristol School at Brooklands. In the first World War he served with the Royal Flying Corps and the Royal Air Force, and for part of the time was seconded to William Beardmore and Co., Ltd., to work on engine design. After the war Major Halford joined the staff of Ricardo and Co., Ltd., and was engaged on engine design work both in this country and in the U.S.A. Later, he became engine designer to A.D.C. Aircraft, Ltd., and consulting engineer to Vickers, Ltd., and in 1927 he was appointed to the full-time staff of the de Havilland Aircraft Company, Ltd. In 1935, Major Halford joined D. Napier and Son, Ltd., as technical director, and in 1944 he was mainly responsible for the formation of the de Havilland Engine Company, Ltd. He is now chairman and technical director of that company and a director of the de Havilland Aircraft Company, Ltd. It is of interest to recall that Major Halford designed a 1½-litre, six-cylinder racing car engine running at 6000 r.p.m., and that he has won many races at Brooklands in his own Halford car powered by this engine.

Launch of H.M.S. "Duchess"

On April 9th, H.M.S. "Duchess," the seventh vessel of the "Daring" class of destroyers, and the fifth vessel to bear the name, was launched from the Woolston Works of John I. Thornycroft and Co., Ltd. The naming ceremony was performed by the Countess Mountbatten of Burma, who had specially returned from India to carry out her promise to act as godmother to the ship. In common with other ships of the class the new destroyer has an overall length of 390ft, a beam of 43ft, and will carry a main armament of six 4·5in guns mounted in twin turrets. Six other guns will form the anti-aircraft defence, there will be two pentad torpedo tubes, and the ship will be equipped with the finest anti-aircraft and anti-submarine equipment yet devised. Habitability is the keynote in the design of the accommodation and the vessel will have all-electric equipment, including special labour-saving devices for cleaning ship. The geared turbine machinery, taking steam from controlled superheat boilers, is being constructed by the ship builders, and is of advanced design, the steam conditions being the highest yet used by the Royal Navy. Similar sets of machinery have been the subject of exhaustive proving tests and consumption trials at the Pametrada research station, where the staff has devised the instrumentation for measuring the efficiency and performance of the machinery. To meet the requirements of the increasing number of electrically controlled instruments the vessel will have a three-phase a.c. installation operating at 440V and 60 c/s.

Historic Development of the Theory of the Flow of Water in Canals and Rivers*

By SERGE LELIAVSKY BEY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. I

Some General Principles of Uniform Flow

THAT the amount of flowing water varied with the size of the river was probably perceived by the human brain in the earliest stages of its evolution, but the modern parameter, which serves to define and gauge this amount, i.e., the discharge, was not understood until comparatively quite lately, viz., the earlier part of the seventeenth century; in fact, it was first mentioned[1] by Castelli,[2] in his treatise "Della misura del l'acque correnti," published in 1628. Once having realised that, neglecting additions and losses, the discharge of a canal or river remained constant along its length, he came naturally to the conclusion that the velocity was inversely proportional to the sectional area. The publication of this work can therefore be considered as the starting point in the development of modern hydraulics.

From that date onwards, the progress of mechanical hydraulic knowledge has been practically uninterrupted. But, unfortunately, it has been handicapped by the existence of a number of basic fallacies, which still influence some modern publications on hydraulics. For instance, the table of Bazin's discharge coefficients which appears in almost every textbook on the subject, includes occasionally a specific type of channel described as a wooden trough with battens inside, so many inches apart.[3] The *raison d'être* of such an entry is difficult to explain, unless one realises the derivation of Bazin's coefficients. When they first began their investigation, d'Arcy and Bazin had a very definite objective before them: to combat a popular heresy of their period according to which the discharge was said to be independent of the physical characteristics (rugosity) of the channel. In order, therefore, to produce a spectacular demonstration of the fallacy of the principle they were fighting, they experimented upon artificially-created extreme conditions. Hence, the battens in the wooden trough.

When first produced, the quantitative result thus obtained was indeed of remarkable interest, but in the course of years the point of the controversy was gradually forgotten, and the reference to this specific channel appears now to be lacking in relevance. Unless, therefore, the historical background of the experiment is fully explained, the reference serves only to encumber the brain of the student with apparently useless numerical material.

Another instance within the same group of mistaken ideas is the belief, still held by many modern hydraulic engineers, that the maximum velocity in a river is located at some depth below the water surface. Here again, the past history of hydraulic science, particularly the "scala" fallacy, plays an important part in affecting, through the textbook, the general trend of technical engineering opinion. These, and many other similar instances, warrant a historical approach to the study and teaching of hydraulics.

We will, therefore, begin with a list, or "catalogue," of historical fallacies which have influenced the gradual development of canal hydraulics, and have thereby affected its present structure. This list comprises three essential entries, as follows:—

(*a*) The fallacy of the "scala."

(*b*) The friction fallacy of Galileo.

(*c*) The fallacy of the independence of the flow from the physical characteristics of the channel.

These three main subjects are selected for study from among many other secondary errors, for they led, in the past, to animated debates which lasted throughout many decades. Up to a point, their individual histories are interrelated; which has to be taken into account in explaining the subject.

The Scala Fallacy

A disciple of Galileo, the well-known Toricelli, is responsible for the error of the "scala." Among his many outstanding discoveries he found that the jet of water issuing from a vessel (see Fig. 1*b*) at a depth

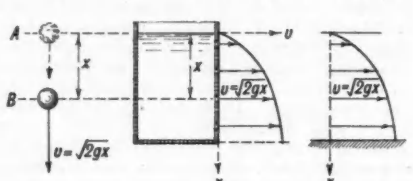


FIG. 1

x from the surface had exactly the same horizontal velocity, $\sqrt{2gx}$, as the vertical velocity of a falling body (see Fig. 1*a*) at the same vertical distance x from its original position.[4] His mistake resided in the fact that he assumed that the same law applied as well to the flow of water in a canal or a river. This gave, therefore, a parabolic diagram, or "scala," for the velocity distribution over a vertical line with zero at the top, and a maximum at the bed of the channel (see Fig. 1*c*).

That such an error could ever have been committed appears almost unbelievable to us, because we are used, now, to the nineteenth century concept of "friction" between the water and the solid trough; we therefore automatically object to the idea that the maximum velocity is at a point nearest to the bed, where the flow of the water meets the greatest resistance. But it must be realised that in Toricelli's time water was commonly believed to be an ideal fluid, "viscous friction" and other similar concepts having been introduced much later.[5] This brings us back to what was described earlier as the "friction fallacy of Galileo." In fact, the great master himself did not realise that the surface of contact between the moving water and the solid trough was the source of the retarding effect exerted by the channel upon the flow; which effect, according to the classical theory of the late nineteenth century, was described as, and assimilated to, the "friction" between solid bodies.

Galileo had shown earlier that, in spite of the difference in the shape of the channels along which they run, the balls *A* and *B* (see Fig. 2) reached the end of their courses

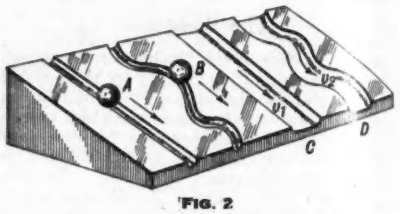


FIG. 2

simultaneously; which was of course true, because the friction force was under these conditions negligible. But here again, as in the case of Toricelli's "scala," an error was made in generalising to a wider field, conclusions arrived at under certain specific conditions, which qualified the scope of application of the results of the tests. In fact Galileo fell into the error of believing that the more general problem of open channels could be solved by analogy with his experiment on balls, which meant that the velocity of water in the canals *C* and *D* (see Fig. 2) was the same, notwithstanding the difference in the length of their respective channels. The following abstract from his letter to Rafaello Stacolli is characteristic of his misconceptions on the subject[6]: "In what concerns the curves and bends of canals, I may go as far as to accept that angles formed by straight lines, particularly if such angles are sharp or straight, or nearly straight, may create resistances to the flow of water. But in the case of blunt angles, even if formed by straight lines, the resistance must be very small. In dealing, however, with a naturally meandering river, the bends of which are all curves, I definitely believe that the resistance afforded to the flow is negligible." Galileo's views on the matter had, unfortunately, far-reaching influence on the development of canal hydraulics; in fact, his error was not corrected until a 150 years later.

Reverting again to the problem of the "scala," Toricelli's erroneous postulate re-appears fifty years later in the works of another well-known Italian of the period, Guglielmini ("Della natura de fiumi," 1697), whilst Grandi, though he also adopts the parabolic scala, places, nevertheless, its apex somewhat above the water surface ("Del movimente dell'aqua . . ."). The same opinion is held by Frizi ("Del moto di regolare i fiume i torrenti").

Curiously enough, the belief that the velocity in a vertical direction increased with the depth of the water from the surface was at that time confirmed by field observations, carried out by numerous Italian engineers, amongst whom may be mentioned Zendrini (1679–1747), Lecchi (1702–1776), Michelotti (1710–1777), and Lorgna (1730–1796).

Fig. 3 shows diagrammatically some of the apparatus used by these engineers, and explains, in each case, the cause of the error. It seems, however, that apart from defective apparatus, the regrettable but very human tendency to conform with an already generally accepted standard theory influ-

* The opinions expressed in this article are those of the author and do not necessarily represent those of the Egyptian Ministry of Public Works.

[1] Professor Dr. M. Ruhlmann, "Hydromechanik," Hannover, 1880, page 339.

[2] Monk of the famous Monte Cassino Monastery; disciple and closest friend of Galileo; took part in his fight against the Roman curia.

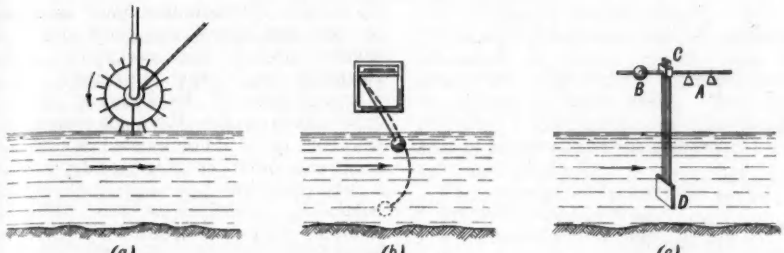
[3] Cf., "A Review of Flow in Pipes and Channels," by S. J. Davies and C. M. White, *Engineering*, July 26, 1929, page 98, Table II, Entries 28 to 34, described as: Rough wooden open channel, rectangular. Artificially roughened by wooden slats, &c.

[4] "Del moto dei gravi," Florence, 1644.

[5] In Newton's "Principia . . ." 1687.

[6] "Lettera di Galileo Galilei sopra il fiume Bisenzio a Rafaello Staccoli. Da Bellosguarda li 16 Gennajo 1630." The abstracted text is a free translation.

enced the conclusions arrived at by these authors, as is so often the case with published field observations. For any figure which disagrees with such a theory is believed to be an anomaly, and is automatically rejected. It is, therefore, to the credit of the quoted authors that some of them (Zendrini and Lechi) placed on record their doubts on the subject, stating that their results were often contradictory. The first, however, who openly dared to object against the generally accepted theory was the Frenchman Mariotte, who, it may be noted, was also the first to point out Galileo's error in connection with the stress-distribution problem in beams.



(a) Author unknown; first mentioned in Leupold's "Theatrum Machinarum Generale" in 1724. Used in Italy by Muratori, Gennete and Michelotti for measuring surface velocities. Observations underestimated because of effect of water lifted by paddles.

(b) Employed by Zendrini, Lecchi, Lorgna, Michelotti and others. Velocities deduced from angle of inclination of rope. As the curvature of the rope (see dotted line) is not accounted for, velocities at lower levels are overestimated.

(c) Velocities calculated from variable loads A as compared with constant B. Used by Michelotti in 1771 and by others. Velocities of the deeper layers of water over-estimated because impact on lever CD is neglected.

FIG. 3

Mariotte's observations[7] were carried out with a device known as a "double float," made of two floats attached by a string and weighted respectively in such a manner that one of them remained always on the surface, while the other moved at some given depth below the surface.[8] In this manner, Mariotte proved that the velocity gradually decreased towards the bed of the channel, except in the immediate vicinity and upstream of weirs. His observations were made on very small canals only, but were soon confirmed on a much larger scale by another Frenchman, Pitot, who invented the apparatus which still bears his name. Using it on the Seine, near Paris, he came to the same conclusions as Mariotte.

Further experimental confirmation of the same principle was supplied by Ximenes in Italy (1780) and Brunnings in Germany (1780–1792). The numerical data published by these observers were subsequently analysed by Eytelwein (1801), who found them somewhat contradictory, and suggested, therefore, that the linear diagram

$$v=(1-0{\cdot}0127x)v_{max}$$

was as good a fit as any other more complicated equation; and by Woltman (1812) who inverted Toricelli's parabola placing its apex well below the bed level, Fig. 4, so that the significant "wetted" part of the curve approached very closely Eytelwein's straight line. As Woltmann's scala was diametrically opposed to the earlier views of the Italian school, it was later described by d'Aubuisson as a "parabole renversée." Thereafter followed the elliptical "scala" of Gerstner (1819) and the logarithmic curve of Funk (1820).

The straight line had also many protagonists, among whom we may quote Du Buat (1801), Prony (1804), Weisbach (1848), and Lachmeyer (1854). On the other hand, Raucourt deduced, from his observations on the Newa (1832), that the scala was a combination of an ellipse near the bed, with a straight line near the water surface, while Defontaine's observations on the Rhine (1833) yielded a combination of two straight lines.

Judging by our present-day standards, the striking point about all these suggestions was the scantiness of the observational material upon which they were based. In fact, half-a-dozen observations were sometimes considered sufficient to develop a new type of scala, which was visualised by its author not only as an empirical approximation, but often as a fully established physical law. It is, therefore, particularly significant that the investigation which will next be quoted, namely that of d'Arcy and Bazin, was systematically planned, and comprised enough data upon which to base fully reliable conclusions. In particular, it showed the effect of the side slopes of the canal upon the scala, a point which until then had been entirely missed.

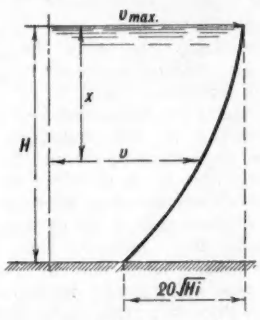


FIG. 4

At the earlier stage of the investigation Bazin acted as assistant to d'Arcy, but on the death of the latter, which occurred in 1858, he took charge of the whole work and completed it, in 1860, with remarkable skill and deep insight. The hyperbolic anagram is one of the characteristic points of the methods he used in systematising his results. It was definitely established by these experiments that in a natural river or wide canal the maximum velocity was at the surface. In the middle of such streams, where the hydraulic effect of the side slopes was nil, the scala was shown to be a parabola with a horizontal axis (see Fig. 4), the equation of which was $\frac{v_{max}-v}{\sqrt{Hi}}=20\left(\frac{x}{H}\right)^2$, in which i is the slope and H the total water depth (in metres).

On the other hand, for narrow canals, the width of which was less than five times their depth, the maximum velocity was below the surface; in fact, the closer to the banks the deeper was the maximum. This effect was illustrated by Bazin by means of diagrams, showing the curves of equal velocities (isotachs), one of which is reproduced in Fig. 5.

Critics of Bazin's scala pointed out that it was highly improbable that the same numerical parameter should apply to canals of very different roughnesses. That is of course true, and the point has been corrected by subsequent research (Pressey's investigations, &c.).

It might have been expected that the exhaustive investigations carried out by Bazin, relating as they did to eighty-two different channels, every one of which was tested under a variety of hydraulic conditions, would have settled the main point of the two-centuries old controversy about the scala; or at least formed the starting point for any further, more advanced, research in this particular line of experimental hydraulics. This, however, was by no means so. Concurrently with, and in the years following, the publication of Bazin's "Recherches Hydrauliques" (1865) we find various suggestions for velocity diagrams with the maximum again at a certain depth below the surface. They show how very deeply rooted was the influence of earlier misconceptions!

For instance, Humphreys and Abbot, using, on the Mississippi, Leonardo da Vinci's antiquated double-float, concluded that the maximum was at 0·317 of the water depth

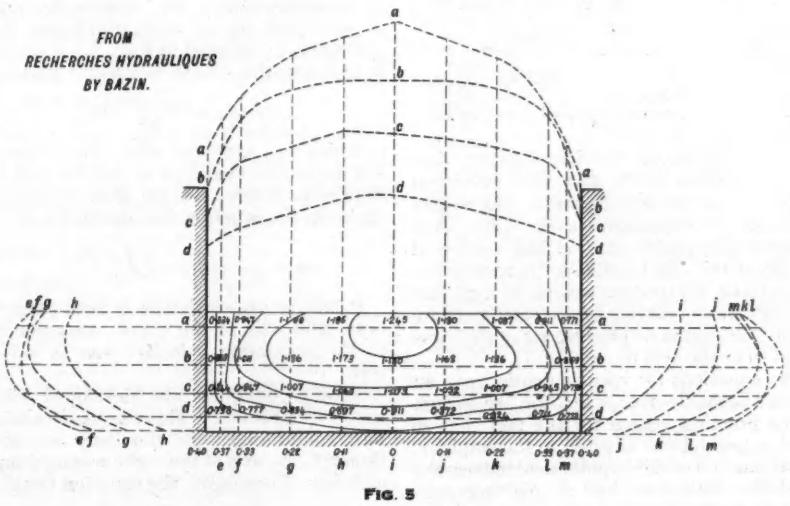


FIG. 5

[7] "Traité du mouvement des eaux," 1700.

[8] This device had already been used by Leonardo da Vinci.

from the surface[9] (which was, of course, due to the misleading effect of the impact upon the string connecting the floats), while Harder gave a scala composed of two ellipses, cotangent to a vertical line in the point of the maximum velocity, at some distance below the surface.[10] A still more complicated curve,

$$v=\sqrt{2ax}+\sqrt{2b(H-x)}+c$$

was devised by Heszle.[11] In this latter case, the curve was tangent both to the bed of the channel and to the water surface, as if the latter caused a retarding effect similar to that of the former.

In contrast to these old-fashioned formulæ, there should be mentioned three valuable post-Bazin investigations, carried out respectively by Pressey, in America, and by Jasmund and Bolte, in Germany. These publications may be considered as completing the cycle of empirical attempts at a general solution of the scala problem.

Pressey improved[12] Bazin's results in that he succeeded in tracing quantitatively the effect of the roughness of the channel on the shape of the scala. From seventy-eight curves, derived from observations on eight rivers near New York, he concluded

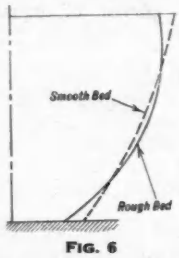


FIG. 6

that the roughness of the channels caused the curvature of the scala to increase (see Fig. 6).

R. Jasmund attempted a much more ambitious problem: to determine the most probable equation for the scala by means of the least squares method.[13] To that end, he examined statistically 445 velocity diagrams based upon his observations on the Elbe. Four different equations were tried, and the following probable errors (in millimetres per second) were obtained :—

Type of curve	Probable error, millimetres per sec.
Parabola with horizontal axis : $v=a+bx+x^2$	18·4 to 63·9
Parabola with vertical axis : $x=a+bv+cv^2$	24·5 to 53·4
Hyperbola : $(v-b)(x+a)=C$	6·6 to 27·5
Logarithmic curve : $v=a+b\log_e(x+c)$	0·9 to 25·4

It followed from this investigation that the logarithmic curve was best suited to represent the velocity diagram. The results obtained by Jasmund on the Elbe were subsequently (1916) verified and confirmed by Bolte on the Warthe.[14] A number of different curves (sixteen conical sections and two logarithmic curves) were tested, and here again the formula $v=a+b\log(y+c)$ was found to be the best fit (see Fig. 7).

The equations for various depths gave an average probable error of 5·6 mm per second.

The practical reason for the fact that so much attention was devoted to the empirical determination of the hypothetical universally applicable scala was that at this time engineers wanted to obtain a general rule for calculating the discharge from surface-float observations. Since then, however, the use of the current meter has gradually been popularised. It constitutes nowadays, in combination with the planimeter (according to the Harlacher's graphical method of

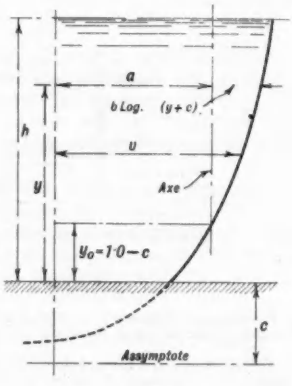


FIG. 7

discharge computation), the standard method for stream gauging adopted almost exclusively in all branches of canal and river engineering. This explains why less attention was devoted to the problem under consideration in the earlier part of the present century than in the past.

Latterly there seems, however, to be a renewal of interest in the subject. It appears to be chiefly due to two reasons :—

(*a*) A tendency to verify the Prandtl-Karman semi-rational approach in problems relating to turbulence.

(*b*) A generally recognised "feeling" that the mechanics of silt transport, which has found expression in various theories of silt-stable channels, is closely related with the shape of the vertical velocity curve.

As both these points are of considerable interest to the engineer, the quesiton of the "scala" must now be considered from another standpoint; namely, that of theory. Viewed from this angle, the general outline of the evolution of the problem was as follows.

Neglecting the earlier fallacies of the Italian school, the first solution of the problem calling for record was supplied by Dupuit. In his well-known work "Études theoriques et pratiques sur le mouvement des eaux courantes," published in 1848, he developed, from theoretical considerations the equation :

$$v=v_{max}-\frac{v_{max}-v_{min}}{H^2}x^2,$$

in which v_{max} and v_{min} were the maximum and minimum velocities at surface and bed level respectively. In the second edition of his book, the equation was modified to

$$v=v_{max}-(v_{max}-v_{min})\left(\frac{x}{H}\right)^{\frac{n+1}{n}}$$

It will be observed that in both cases the horizontal axis of the curve, corresponding to the maximum velocity, was at surface level.

Another equation was developed analytically by Grashof.[15] This was also a parabola but, conforming with the older school of thought, the axis of the curve was at a depth a_o below the surface; the equation being :—

$$v=v_{max}-m(x-a_o)^2.$$

Though his formula was less advanced than that of Dupuit, Grashof realised the limitations of the theoretical concepts used by both of them as basis for their deductions. In particular, that water was assumed to move along smooth parallel courses, whilst in nature the paths of the water particles were anything but smooth and regular. Thus, by the middle years of last century, the more advanced hydraulic engineers had begun gradually to realise that the basic assumptions of their theoretical analysis disagreed with nature; but it was not until 1883 that the essence of "turbulent flow," as opposed to "laminar flow" was fully understood, chiefly through the works of Osborne Reynolds, and other physicists of the "English School." By means of his famous experiments on pipes, Reynolds demonstrated that both types of flow existed in nature, the occurrence of one or other type depending on a "dimensionless" parameter, which is now commonly described as the "Reynolds number," and is designated by the capital letter R.

According to Reynolds' original work[16] there existed two critical values of R. Below the lower limit the flow was always laminar and above the upper limit it was necessarily turbulent, whilst in the region in between the two limits, both types of flow were possible, depending on secondary circumstances.

Subsequent research showed that the lower limit only (about R=2000 for cylindrical pipes) had an intrinsic, rigid value, whereas the upper limit depended on the testing apparatus and experimental procedure adopted. This, however, is a point of secondary importance only, for the main significant conclusion of Reynolds' results, in so far as our subject is concerned, is that in all cases of a practical engineer's professional life he encounters conditions far above the critical values of Reynolds number and deals, therefore, always with turbulent flow (except where underground seepage is concerned).

Almost at the same time as Reynolds' experiments were carried out in England, theoretical investigations of considerable importance were published on the Continent by Boussinesq.[17]

In various hydraulic problems, as well as in several other fields of engineering inquiry, Boussinesq's results are still valid. In so far, however, as the "scala" problem is concerned, particularly in regard to the turbulent nature of the flow, Boussinesq's results have been superseded by more advanced, later research. Boussinesq's merit in this line of investigation was to have openly attacked the problem of "tumultuous and eddying movement of the running water," but the only result he succeeded in obtaining was the parabolic diagram which, strangely enough, agreed with Bazin's scala, not only in its symbolic form, but included also the same numerical coefficients.

(*To be continued*)

DEEP WATER BERTH AT DAR ES SALAAM.—The Colonial Office says that an agreement has been signed between the British Government and the Belgian Government providing for the construction of a deep water berth at Dar es Salaam, British East Africa, for Belgian use. The berth is in addition to the two deep water berths under development at Dar es Salaam for the East African Railways and Harbours Administration. It will be built at Belgian expense and will replace the existing Belgian enclave in Dar es Salaam, which at present is operated, as in the rest of the port, by lighterage. The work on all three berths, which will be carried out by J. L. Kier and Co., Ltd., of London, will begin very shortly; it is expected to take about three and a half years.

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[9] "Report Upon the Physics and Hydraulics of Mississippi," 1861. Actually this report appeared before that of Bazin, but it is understood that Bazin's investigations were known to the American authors when they carried out their observations.

[10] "Die Theorie der Bewegung des Wassers . . .," 1878.

[11] "Zeitschrift für Gewasserkunde," 1899.

[12] U.S. Geological Survey, Paper 76, 1903.

[13] "Zeitschrift für Bauwesen," 1893–1897.

[14] See "Zeitschrift für Bauwesen," 1916.

[15] "Theoretische Maschinenlehre."

[16] "An Experimental Investigation of the Circumstances which Determine Whether the Motion of Water Shall be Direct or Sinuous," "Phil. Trans.," Royal Soc., 1883.

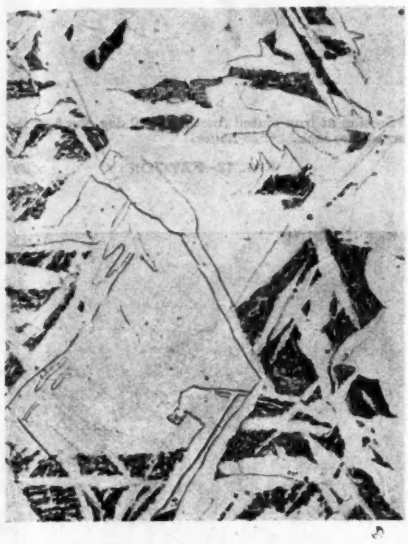
[17] "Essai sur la théorie des eaux courantes," Memoires pres. p. div. sav. à l'Acad. des Sc., 1877, and "Théorie de l'Ecoulement tourbillonant et tumultueux des liquides," Paris, 1897.

Microscopical Examination of Creep Specimens

By E. A. JENKINSON, M.Sc.*

THIS article forms an Appendix to the article "Fracture under Combined Stress Creep Conditions of a 0·5 per cent Mo Steel," by A. E. Johnston and N. E. Frost, published on page 434 of our issue last week.

The test specimens were made from a casting 7in square and 17in long of a



Material before test

FIG. 1—CAST FZW ×150

0·5 per cent molybdenum steel. This was tested in the "as-cast" state. Considerable study of the creep properties of this steel in

Material before test

FIG. 2—CAST FZW ×500

the form of hot-rolled bar† had already been carried out.

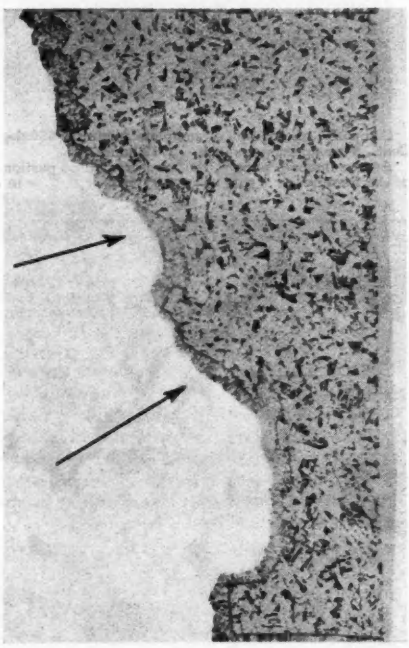
The steel presented a typical cast structure consisting of coarse pearlite and ferrite grains (Figs. 1 and 2), but there was a marked variability in grain size. The pearlite exhibited a Widmanstatten appearance (see Fig. 1), which also differed in degree from one specimen to another.

Two types of test piece were examined :—

(*a*) Solid test pieces, and

(*b*) Thin-walled tubular test pieces.

Tensile creep tests at 550 deg. Cent. had



Composite photograph of complete fracture of FZW7D4, 550 deg. Cent., 13 tons per square inch, 186 hours.

FIG. 3 ×10

been carried out on the solid specimens and the results are given in Table I. On the tubular specimens tensile and torsion stresses had been imposed. The results of these tests are given in Table II.

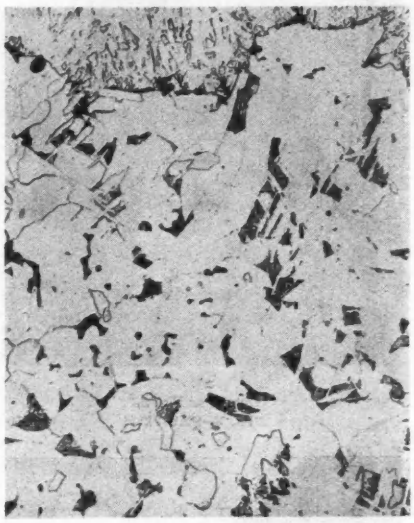
TABLE I.—*Creep Tests on Solid Tensile Specimens at 550 Deg. Cent.*

Test piece number and letter	Stress in tons per square inch	Time to fracture in hours	Elongation, per cent (4/area)
FZW7D4 ...	13	186	0·7
FZW7D1 ...	9	1550	1·8
FZW7D8 ...	8	2712	4·0
FZW7D5 ...	7	4738	3·1

TABLE II.—*Creep Tests on Thin-Walled Tubular Specimens at 550 Deg. Cent. in Pure Torsion and Combined Stress Systems*

Test piece number and letter	Torsion stress, tons per square inch	Tensile stress, tons per square inch	Time to fracture in hours
FZW7Z3... ...	6·5	0	1403
FZW7Z1... ...	1	9	556
FZW7Z2... ...	5	9	234
FZW7Z5... ...	8	4	231

For the microscopical examination the fractured test specimens were sectioned and polished. (To support the fractured surface a heavy electrodeposit of iron was first plated on to the fractured specimen before



Section at iron-plated fracture. For details of test see Fig. 3.

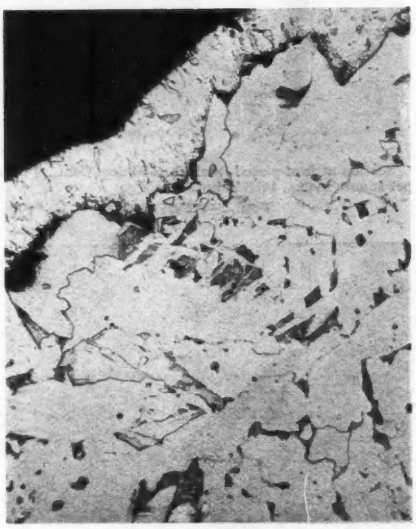
FIG. 4—FZW7D4 ×50

sectioning, thus enabling a flat polished section to be obtained, which could be examined right up to the fracture.) Photomicrographs, Figs. 3–22, illustrate the structural condition of the various test specimens.

MICROSCOPICAL EXAMINATION OF FRACTURED SPECIMENS

1. *Solid Tensile Specimens Tested at 550 Deg. Cent.*

(a) *FZW7D4 (13 Tons Per Square Inch, 550 Deg. Cent., 186 Hours).*—The structure



Section at iron-plated fracture and surface. 550 deg. Cent., 9 tons per square inch. 1550 hours.

FIG. 5—FZW7D1 ×50

of a section at the fracture of this test piece is shown in the composite illustration Fig. 3, taken at a magnification ×50 and reduced for reproduction. Much of the fracture passes around the grain boundaries and is intercrystalline (Figs. 3 and 4), but in a few places fracture occurs across the grains. (Arrows indicate the small transcrystalline portions of the fracture in Fig. 3.)

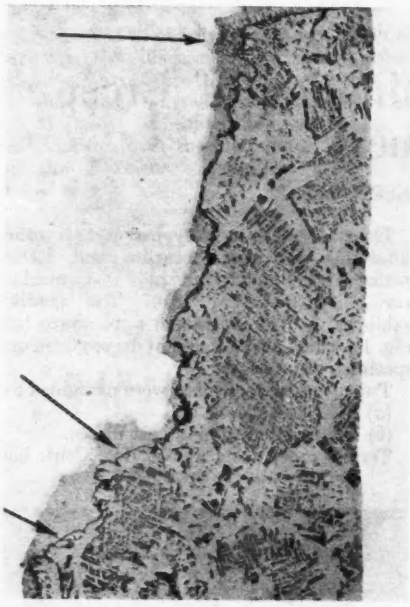
* Metallurgy Division, National Physical Laboratory.

† "The properties and mode of rupture of a molybdenum and a molybdenum-vanadium steel, judged from prolonged creep tests to fracture" by H. J. Tapsell, C. A. Bristow, and C. H. M. Jenkins, "Proc.," Inst. Mech. Engrs., Vol. 146 (1941), page 208.

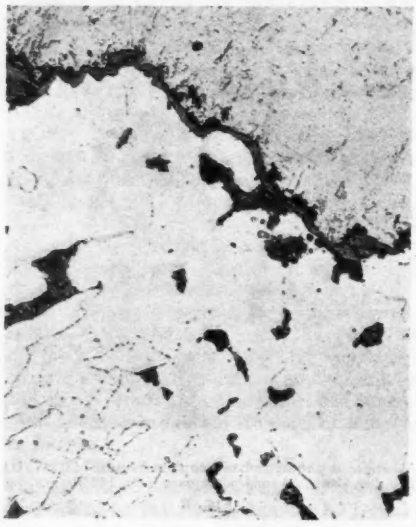
Details as Fig. 5.
FIG. 6—FZW7D1 ×150

Section at iron-plated fracture. 550 deg. Cent., 9 tons per square inch. 1550 hours.
FIG. 7—FZW7D1 ×500

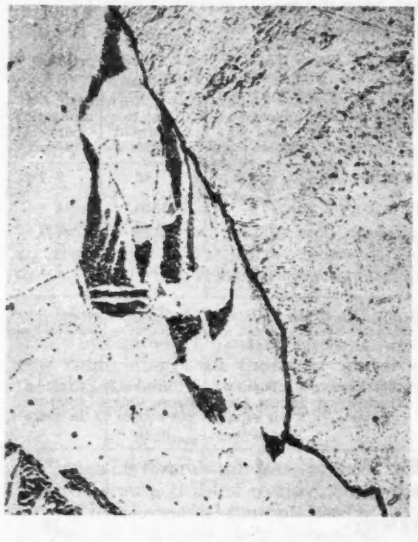
Intercrystalline cracking close to fracture. Details of test as in Fig. 7.
FIG. 8—FZW7D1 ×1500



Composite photograph of complete fracture. 550 deg. Cent., 8 tons per square inch. 2712 hours. Arrows indicate some of the transcrystalline portions of the fracture. FIG. 9—FZW7D8 ×10



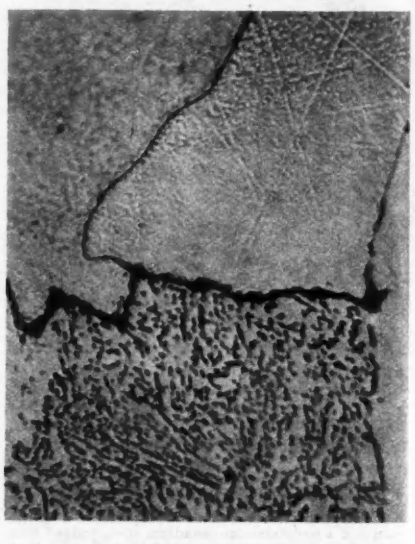
Section at iron-plated fracture. Details of test as in Fig. 9.
FIG. 10—FZW7D8 ×150



Section at iron-plated fracture. 550 deg. Cent., 8 tons per square inch. 2712 hours.
FIG. 11—FZW7D8 ×150

Section at iron-plated fracture. 550 deg. Cent., 7 tons per square inch. 4738 hours.
FIG. 12—FZW7D5 ×150

Section at iron-plated fracture. Details of test as in Fig. 12.
FIG. 13—FZW7D5 ×500



Section close to fracture. Details of test as in Fig. 12.
FIG. 14—FZW7D5 ×1500

(b) *FZW7D1* (*9 Tons Per Square Inch, 550 Deg. Cent., 1550 Hours*).—The fracture of this specimen is generally intercrystalline and is very similar to the previous specimen (Figs. 5, 6 and 7). In a few places fracture

Iron-plated section through wall of tubular specimen. 550 deg. Cent. Tension 9 tons per square inch. Torsion 1 ton per square inch. 550 hours.

FIG. 15—FZW7Z1 ×150

has occurred across the grains. Further evidence of the intercrystalline character of the cracking is given by the separation along grain boundaries found close to the fracture (Fig. 8). Some spheroidisation of the carbide in the pearlite areas is also to be found together with some carbide particles, in the grain boundaries (Figs. 7 and 8).

(c) *FZW7D8* (*8 Tons Per Square Inch,*

Iron-plated section at fracture of tubular specimen. 550 deg. Cent. Tension 9 tons per square inch. Torsion 5 tons per square inch. 234 hours.

FIG. 16—FZW7Z2 ×500

550 Deg. Cent., 2712 Hours).—A composite photograph of a section at the fracture is shown in Fig. 9. This shows that the fracture is still mainly intercrystalline (see also Fig. 10), but the proportion that is transcrystalline represents about one-quarter of the fracture (see Figs. 9 and 11). The fracture also shows a tendency to occur along the line of the ferrite network around the patches of Widmanstatten structure (Fig. 9). Some elongation and distortion of the ferrite and pearlite grains has occurred at and close to fracture (Figs. 9 and 11). The carbide of the pearlite grains has spheroidised considerably and there are a number of carbide particles in the grain boundaries (Figs. 10 and 11).

(d) *FZW7D5* (*7 Tons Per Square Inch, 550 Deg. Cent., 4738 Hours*).—In this

Intercrystalline cracks away from fracture. 550 deg. Cent. Tension 9 tons per square inch. Torsion 5 tons per square inch. 234 hours.

FIG. 17—FZW7Z2 ×150

specimen the fracture is again mainly intercrystalline (Fig. 12) with about one-quarter transcrystalline (Fig. 13). Internal cracking close to fracture occurs along grain boundaries (Fig. 14). The carbide of the pearlite shows spheroidisation (Figs. 12 and 14). Considerable distortion of some of the pearlite

Necking down of wall of specimen away from fracture. Details of test as in Fig. 17.

FIG. 18—FZW7Z2 ×150

and ferrite grains has occurred at fracture (Fig. 13).

2. *Thin-Walled Tubular Test Pieces Tested at 550 Deg. Cent.*

(a) *FZW7Z1* (*Torsion 1 Ton Per Square Inch, Tensile 9 Tons Per Square Inch, 556 Hours*).—The fracture of this specimen is mainly intercrystalline, but there are some portions which are transcrystalline; Fig. 15 shows a photomicrograph of a section through the wall close to the fracture. The cracks penetrating from the inner and outer surfaces are both intercrystalline.

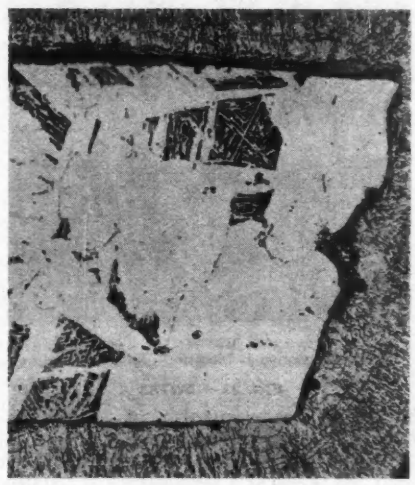
(b) *FZW7Z2* (*Torsion 5 Tons Per Square Inch, Tensile 9 Tons Per Square Inch, 234 Hours*).—This specimen shows both intercrystalline and transcrystalline breakdown (Figs. 16 and 18). The necking down of the

Transcrystalline portion of fracture. 550 deg. Cent. Tension 4 tons per square inch. Torsion 8 tons per square inch. 231 hours.

FIG. 19—FZW7Z5 ×150

wall of the specimen shown in Fig. 18 has occurred away from the main fracture, part of which is shown in Fig. 16. Intercrystalline cracks penetrating from the wall of the test piece are shown in Fig. 17. Considerable elongation of the ferrite and pearlite grains has taken place where the fracture is occurring in a transcrystalline manner (Fig. 18).

(c) *FZW7Z5* (*Torsion 8 Tons Per Square Inch, Tensile 4 Tons Per Square Inch, 231 Hours*). The wall of the specimen has fractured in both an intercrystalline and a transcrystalline way. Photomicrographs (Figs. 19 and 20) illustrate the two types of fracture. Elongation of the ferrite and pearlite grains is considerable in the transcrystalline parts (Fig. 19), but no apparent distortion of



Intercrystalline portion of fracture. Details of test as in Fig. 19.

FIG. 20—FZW7Z5 ×150

grains is evident in the intercrystalline portions of the fracture (Fig. 20).

(d) *FZW7Z3* (*Torsion 6·5 Tons Per Square Inch, Tensile 0 Tons Per Square Inch, 1403 Hours*).—Part of the fractured wall of this test specimen is shown in Fig. 22 and in general appears to be transcrystalline, though little distortion or elongation of the grains

has occurred at fracture. Intercrystalline separation of grains is found away from the fracture in the body of the wall (Fig. 21).

Summary

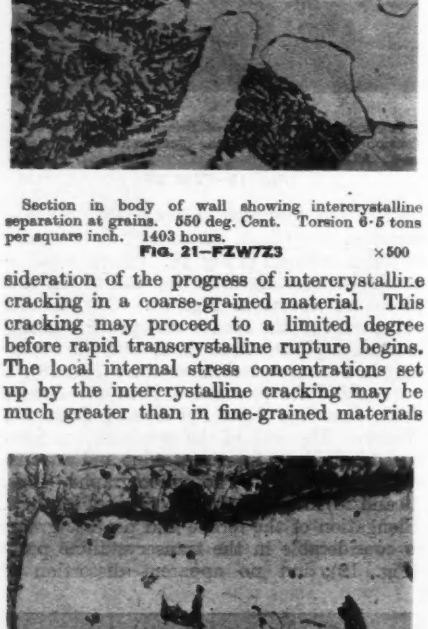
There is a general difficulty due to the absence of much previous work in the consideration of the progress of intercrystalline cracking in a coarse-grained material. This cracking may proceed to a limited degree before rapid transcrystalline rupture begins. The local internal stress concentrations set up by the intercrystalline cracking may be much greater than in fine-grained materials having a greater number of evenly distributed intercrystalline cracks.

In the tensile creep tests carried out on solid test pieces at a temperature of 550 deg. Cent. the fractures appear mainly intercrystalline in the range of stresses used.

However, in the creep tests on the thin-walled tubular specimens, in which pure torsion stresses and a combination of tensile and torsion stress was applied, there is evidence of a general trend, after making allowance for the general coarseness of the material, for the fracture to occur more readily across the grains (i.e. is transcrystalline) than around the grains, with increasing torsion stress.

Section in body of wall showing intercrystalline separation at grains. 550 deg. Cent. Torsion 6·5 tons per square inch. 1403 hours.

FIG. 21—FZW7Z3 ×500

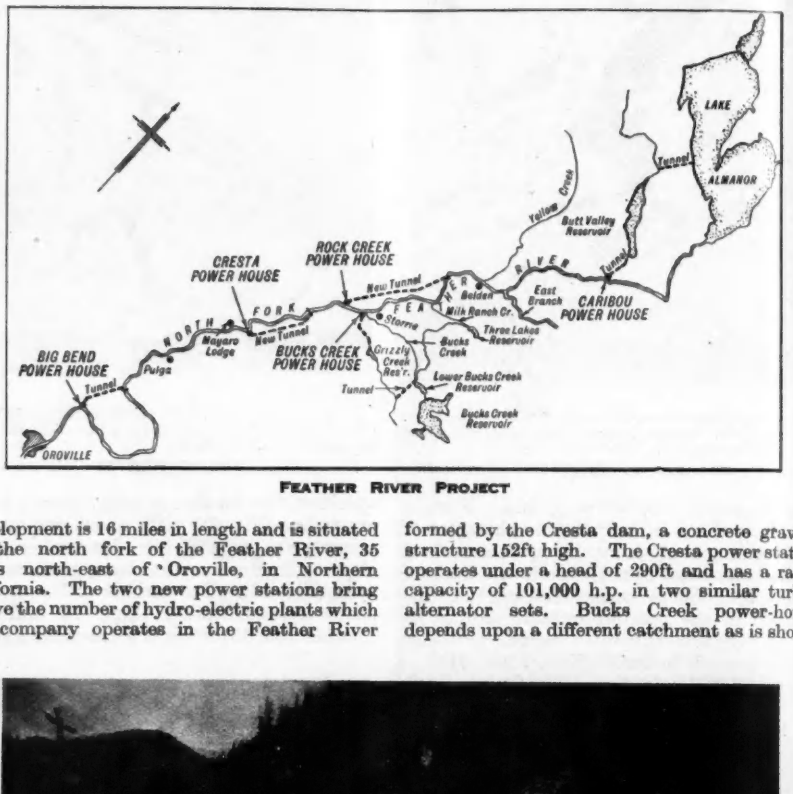


Iron-plated section at fracture. Details of test as in Fig. 21.

FIG. 22—FZW7Z3 ×150

The Feather River Hydro-Electric Project, California

CONSTRUCTION was recently completed of the Feather River hydro-electric power project of the Pacific Gas and Electric Company. The completion of the last two dams—Rock Creek and Cresta—means an increase in installed capacity of 270,000 h.p. to a total of 514,000 h.p., and represents an investment of 61,800,000 dollars. The site of the power development is 16 miles in length and is situated on the north fork of the Feather River, 35 miles north-east of Oroville, in Northern California. The two new power stations bring to five the number of hydro-electric plants which the company operates in the Feather River project, which is shown in the accompanying map.



FEATHER RIVER PROJECT

CRESTA DAM

Further upstream is the 90,000 h.p. Caribou installation, which draws water from Lake Almanor—an artificial lake, which was created by construction of one of the largest earth-fill dams in the world. Downstream from Caribou, near Belden, the new Rock Creek dam has been built. It is a concrete gravity dam, and a tunnel carries the water from the reservoir which it forms to a point 383ft above the power plant; 12ft diameter penstocks then lead to the two turbo-generators, which have a capacity of 169,000 h.p. and operate under a gross head of 535ft. Two miles below Rock Creek power station, water is collected in another reservoir formed by the Cresta dam, a concrete gravity structure 152ft high. The Cresta power station operates under a head of 290ft and has a rated capacity of 101,000 h.p. in two similar turbo-alternator sets. Bucks Creek power-house depends upon a different catchment as is shown in the illustration. It produces 67,000 h.p. and discharges water into the Cresta and Big Bend reservoirs. Big Bend is the final stage of the Feather River system and is rated at 87,000 h.p. Further downstream the water is employed for irrigation.

Rock Creek dam is 2 miles below Belden. It is 115ft above the stream bed and 562ft

long, containing 154,000 cubic yards of concrete. The reservoir has a capacity of 4700 acre-feet, and is 2½ miles long. Two steel drum gates, 28ft high and 124ft long, and one 22ft by 15ft radial gate auxiliary, control the flow of water over the spillway, which has a capacity of 120,000 cusecs. The dam also has three 7ft by 7ft sluice gates and smaller gates which release sufficient water to support fish life in the stream below.

Cresta dam, which is illustrated herewith, is situated in a narrow neck of the Feather River gorge; it has a length of 384ft and a height of 152ft, and contains 79,000 cubic yards of concrete. The dam has drum gates and a radial gate auxiliary of the same dimensions as the one at Rock Creek. For transporting and placing concrete the contractor erected within 100ft of the dam site, a plant consisting of one 3250 cubic foot cement storage silo, one 2500 cubic foot cement batching silo, and a six-compartment concrete batching plant. A derrick was erected over the left abutment, with its 120ft revolving boom within reach of the batching plant. The concrete emplacement began with the blocks of the left abutment; at a later stage, a second derrick with a 100ft boom was erected over the right abutment. For pouring the concrete of the right section, buckets were transferred between the derricks. With only one derrick in operation, the maximum daily pour approached 1000 cubic yards.

The final stages of the Feather River project involved the driving of two horseshoe-shaped tunnels, 25ft to 27ft in diameter, through granite, for a total distance of 10½ miles. Each of the two tunnels was worked in three sections simultaneously. Preparations for blasting were facilitated by the use of a jumbo mounting twelve to fifteen drills, a mucking machine equipped with a conveyor belt being used to load the spoil into dump trucks.

The Cresta tunnel, approximately 21,528ft long, consists of 2995ft of 27ft diameter and 944ft of 19ft diameter round tunnel (including 518ft steel-lined and 44ft of steel-lined sandtrap and transition tunnel); 16,936ft of 26ft horseshoe tunnel, and 653ft of 27ft by 15½ft flattened horseshoe auxiliary tunnel added to the upstream portion of the main tunnel to provide a river diversion round the dam site during construction. Approximately 837ft of tunnel was driven upstream from the diversion adit and the river was diverted in June, 1948.

The Rock Creek tunnel consists of 34,113ft of 25ft diameter horseshoe tunnel excavated from six faces—Chambers Creek and Jackass Creek adits and the two portals. While Cresta tunnel required very little timber support and concrete lining, Rock Creek tunnel, because of the broken formation encountered, required timber support and concrete lining for two-thirds of its length. To guard against possible erosion, several hundred feet of steel liners were installed in the lower end of each tunnel.

The Cresta surge chamber is of conventional design, situated with its top above ground, and is 46ft in diameter by 125ft deep. A 19ft lateral tunnel, 154ft long, connects the bottom of the surge chamber to the 26ft main tunnel. Rock Creek has a subterranean surge chamber, situated directly above the tunnel. A 9½ft by 11ft tunnel, 784ft long, provides access to the subterranean dome over the chamber which is similar in design to the one for Cresta.

The Cresta and Rock Creek tunnels each discharge into twin steel penstocks, 10ft 6in to 12ft in diameter. At the upper end of each penstock a butterfly valve is installed. The Cresta penstocks pass through a culvert under the Feather River State Highway. The Rock Creek penstocks pass under both the Western Pacific Railroad tracks and the State Highway in a tunnel 28½ft wide by 13½ft high and approximately 498ft long. The tunnel was filled with concrete to encase the penstock pipes. The penstocks leading to Cresta power station are 759ft long, and those to Rock Creek power station 930ft long, with a maximum flow of 3500 cusecs in the first case and 3000 in the second.

Both power-house sites are situated between the State Highway and the Feather River. At the Rock Creek power-house the highway was relocated to a position higher in elevation and farther from the river to make room for the new building. Because of the lack of space, a concrete structure was constructed adjacent to the power-house building, which bridges the State Highway and the penstock tunnel portal, and supports the switch structures and equipment. Two 110-ton travelling cranes are installed in Cresta power-house, and two 135-ton cranes are installed in the Rock Creek power-house. The heaviest single piece to be lifted required the combined total capacity of both cranes.

	Cresta	Rock Creek
Horsepower per turbine	46,500	73,500
Speed of turbo-generator, r.p.m.	180	240
Capacity of generator, MVA ...	37·5	63
Power factor (for designed maximum efficiency), per cent	90	90
Generator voltage kV	11·5	13·8
Transmission voltage kV... ...	220	220

The principal characteristics of the two turbo-alternator sets at Cresta and the two at Rock Creek are given in the accompanying table. For transmission the generator voltage is stepped up to 220kV by one transformer bank at Cresta and two at Rock Creek, each provided with a spare unit. There are four transformers, each of 25,000kVA capacity at Cresta and seven, each of 21,000kVA at Rock Creek. A new 220kV line, 30 miles long, was built along the canyon to Oroville. From there, current is transmitted to a substation near Stockton, where general distribution begins. For an average year the two new plants will generate a total of 812,000,000kWh.

The Physical Society's Exhibition

No. II—(*Continued from page 445, April 6th*)

IN this article we continue our descriptive review of some of the instruments and apparatus seen at the Physical Society's Exhibition, which was held at the Imperial College, London, from Friday, April 6th, to Wednesday, April 11th.

Metropolitan-Vickers Electrical Company, Ltd.

An analytical micro-focus X-ray generator is among the apparatus shown by the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17. The equipment, which is illustrated in Fig. 8, is the commercial prototype developed from a laboratory model which was exhibited by the company in 1948. In its present form the generator consists of three units—an X-ray unit, a high-tension d.c. supply unit, and an electrical control unit.

In the X-ray tube assembly a biased electron gun, fed by a shockproof cable, forms a rectangular focal image of the order of 1mm long by 0·1mm wide. An electromagnetic lens produces a reduced image on the target the size of the final focal spot being about 0·1mm by 0·01mm, which, when viewed at a glancing angle of 6 deg., is effectively 0·01mm square. The tube is continuously evacuated and can be operated at 50kV and approximately 700mA; the resulting high intensity of 35kW per square millimetre is due to the extremely narrow focal width. The tube assembly is mounted vertically above a cubicle housing the pumping plant. To give flexibility the pumping plant has been arranged for manual control, but adequate protection has been incorporated. By making use of a high-vacuum valve and by-pass arrangement, filament replacement and target cleaning can be carried out rapidly. All the vacuum plant controls are conveniently mounted in the front panel of the cubicle.

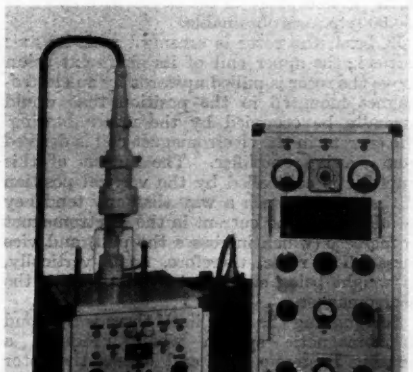


FIG. 8—X-RAY MICRO-FOCUS EQUIPMENT—METROPOLITAN VICKERS

The usual X-ray tube controls and protective equipment, together with the stabilisers for h.t. supply and electromagnetic lens current, are included with the electrical control unit. Constant tube emission is achieved because of the automatic bias which is provided for focusing the beam of electrons in the gun.

The same company is exhibiting a quartz crystal accelerometer head which is designed to measure the linear acceleration of a surface at frequencies in the audio range. It consists essentially of an inertia mass which is kept in contact with a quartz crystal pile by a powerful spring. To make full use of the available frequency range it is essential that the head should be firmly attached to a good machined surface by using either the stud or the clamp provided. For measurements in the frequency range up to 300 c/s, where contact stiffness is less critical, the accelerometer head can be held against the vibrating surface by hand.

Each accelerometer head is calibrated up to a frequency of 10,000 c/s; the useful lower limit, determined by the input impedance of the measuring instrument, is usually in the region of 20 to 50 c/s. The sensitivity is inversely proportional to input capacitance and is about 30mV/g at 100 pF. In its standard form the head is suitable for accelerations up to 500 g but it can be modified to suit larger accelerations, if required. The approximate weight of the head is 1¾ lb and it measures about 2in cube, excluding the top entry connecting lead.

Another exhibit on this stand is an instrument known as the "Varimag" tester, which is capable of being used to detect laminations in sheet steel, internal cavities in welds and variations in the thickness of steel plates, tubes, &c. It operates on the principle that a change of magnetising force H occurs when the structure of a magnetised object changes. Flux is provided by a permanent magnet which can be rotated in a tunnel gap, varying the flux to suit the section of the test piece. Changes in H are indicated by the deflection of a high coercivity magnetic element mounted between the poles of the magnet and close to the surface of the test piece. Movement of the element is indicated on a graduated scale by a balanced pointer.

J. Langham Thompson, Ltd.

A direct-reading tensile load indicator which is useful in the prestressing of reinforced concrete and in the measurement of static loads in tow ropes and haulage cables was among the exhibits shown by J. Langham Thompson, Ltd., Springland Laboratories, Stanmore, Middlesex.

The instrument consists of a strain-gauge dynamometer ring and an indicating unit which takes the form of a robust moving coil

element having a scale length of 3in calibrated for the characteristics of the ring. A measure of the tensile load applied to the dynamometer ring is given by the resultant changes in four strain gauges which are fixed to the ring.

As illustrated in Fig. 9 the indicator unit is housed in an iron-clad enclosure. There are only two controls—a press switch for checking the calibration against an internal standard, and a "press-to-read" switch. A dry battery which is carried within the instrument case constitutes the only power source required, making the equipment completely self-contained and suitable for use by unskilled labour in the workshop or on site. The indicator illustrated in Fig. 9 is one that was recently supplied to one of H.M. ordnance factories. It is a two-channel indicator designed for reading the

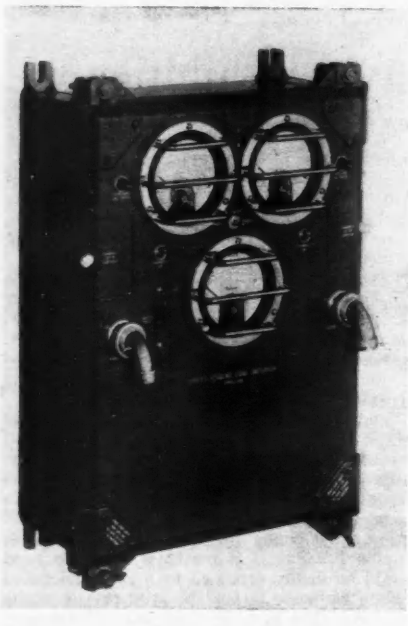


FIG. 9—DIRECT READING TENSILE LOAD INDICATOR—LANGHAM THOMPSON

applied load on each of two reinforcing bars during the manufacture of prestressed reinforcing bars.

Standard dynamometer rings are available for a number of working ranges specified by the following maximum loads:—50 lb, 250 lb, 500 lb, 1000 lb, 2000 lb, 5000 lb and 10,000 lb. In each case the dynamometer element consists of a beryllium copper ring with four resistance strain gauges mounted on the inner surface and at opposite ends of the longitudinal and transverse diameters. This arrangement provides four active resistance elements which are connected electrically as a Wheatstone bridge. For applying the tensile load there are suitably designed lugs fixed at diametrically opposite points on the ring.

The same company also exhibited a control unit for monitoring the operation of automatic packaging machines. The control equipment, which was developed with the co-operation of the Atomic Energy Research Establishment, Harwell, is designed to detect whether cartons leaving an automatic filling and check weighing machine, are, in fact, full. Its operation depends on the fact that the instrument embodies a radio-active source which emits beta particles of sufficient velocity to pass through an empty packet, thereby actuating a detector unit and operating an alarm signal. The presence of a full packet prevents the beta particles from reaching the detector and allows the filling and check-weighing operation to proceed. To prevent false operation due to the passage of beta particles between the cartons a photocell and light source are installed in such a position that the detector can operate only when a carton is present. As soon as each carton passes, the light source illuminates the photocell which, in turn, renders the detector inoperative until the next carton arrives, interrupts the beam of light and restores the detector unit to its operating condition. The instrument is self-contained and is designed to operate from normal a.c. mains.

ARMAMENT RESEARCH ESTABLISHMENT

An interesting exhibit shown by the Armament Research Establishment, Ministry of Supply, is a high-speed camera which has been developed for making photographic records of self-luminous phenomena. The camera is capable of taking a sequence of eighty exposures at a rate of 400,000 per second, a Kerr cell being used to control the duration and timing of each exposure.

Very briefly, the principle of the camera is that a beam of light from the phenomena under investigation is transmitted by conventional optical methods to the centre of a cylindrical enclosure where it impinges on a rapidly rotating plane mirror. Rotation of this mirror causes the beam to scan a series of small equally spaced lenses arranged in an arc of a circle so that each lens is equidistant from the axis of the mirror. On passing through each lens in turn the beam of light falls on a sensitised strip of paper, which is clipped in position on the cylindrical wall of the camera chamber.

Before entering the camera the beam traverses a Kerr cell which is arranged to interrupt the beam 400,000 times a second in exact synchronism with the mirror. The effect of this arrangement is that the beam of light is shut off except for 0·1 microseconds when the beam passes symmetrically through each lens in turn. The effect produced is analogous to that produced by the "gating" in a cinematograph projector. The result on the sensitised paper strip is a series of circular images each of which represents 0·1 microseconds exposure, the interval between successive "shots" being 2½ microseconds.

In the camera as exhibited the mirror is rotated by an air motor, but the Armament Research Establishment is working on a method of suspending the rotor magnetically in a vacuum and driving it by a rotating magnetic field, the object being to reduce bearing friction. An experimental device embodying this idea was demonstrated at the exhibition. In its present stage of development a speed of 100,000 r.p.m. is obtainable.

In brief, the rotor is arranged with its axis vertical; the upper end of its shaft extension above the rotor is pulled upwards by an electromagnet mounted in the position that would normally be occupied by the upper bearing. The current in the electromagnet coil is derived from a valve amplifier. The output of this amplifier is controlled by the vertical position of the rotor in such a way that any tendency to fall causes the current in the electromagnet to increase (which increases the pull) and vice versa. The rotor, therefore, floats vertically, its weight being supported by the pull of the electromagnet.

Surrounding the rotor itself there is a second electromagnetic system which produces a rotating magnetic field and causes the rotor to spin by induction. In operation, then, the rotor has no mechanical support, and mechanical friction, as distinct from windage, is eliminated.

Precession of the rotor when it is running at high speeds is prevented by electromagnetic damping.

BALDWIN INSTRUMENT COMPANY, LTD.

A useful form of industrial instrument for measuring the weight per unit area or the thickness of material (such as paper, board plastic strip or metal foil) during manufacture was exhibited by the Baldwin Instrument Company, Ltd. The "Atomat" beta-ray thickness gauge operates on the principle that beta radiation is stopped by any substance in its path, to an extent proportional to the mass of material traversed. A source of beta-rays in a suitable container, which restricts radiation to the required direction, is placed so that the radiation passes through the material to be measured and falls on a detector. This detector is a sealed chamber containing air which becomes ionised by the radiation and conducts electricity at a rate proportional to the radiation, and, therefore, inversely proportional to mass of material through which it has passed.

In the Baldwin "Atomat," which is illustrated in Fig. 10, the small ionisation current is amplified electronically in the indicating instrument which can be placed in any convenient position up to 50ft from the measuring head itself. There are two indicating meters, one of which gives readings of weight per unit area in any desired units, but, for dealing with any single material of constant density the scale can be calibrated directly in thickness. The other indicating meter shows any deviation above or below a specified thickness or weight.

To maintain a given weight per unit area during any part of a manufacturing process, the deviation indicator is set to read zero at the specified value of weight, by adjusting the control dial on the instrument. Then the

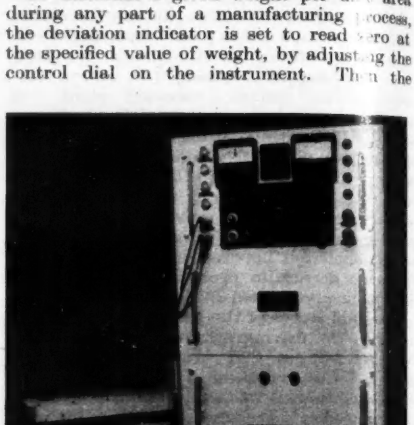


FIG. 10—"ATOMAT" INDUSTRIAL THICKNESS GAUGE—BALDWIN

machine or process is adjusted to keep the pointer of the deviation indicator between the required limits. For this sort of work the gauge is provided with a single measuring head and continuously variable "zero" and "sensitivity" controls for the deviation indicator. Special provisions can be made; for example, instead of having continuously variable control of the deviation indicator zero, a switch can be fitted to give a number of preset positions—a facility which may be useful on a rolling mill where a series of reductions are made on one mill.

Thallium 204 is the standard radio-active source and is mounted in a metal holder approved by the health physics division of the Atomic Energy Research Establishment, Harwell. The casing of the source is provided with a safety shutter whereby all emission is stopped for transport, handling, or checking the instrument setting.

With thallium 204 the range of the gauge is 0mg to 150 mg per square centimetre, which is equivalent to a thickness of about 0mm to 0·55mm in aluminium or 0mm to 0·17mm in brass.

The accuracy in the weight per unit area as indicated by the instrument is stated to be about ±1 per cent at mid-scale. The sensitivity can be expressed by the fact that full-scale deflection of the deviation indicator on the standard instrument is about ±1mg per square centimetre up to 20mg per square centimetre, and ±5 per cent of the weight per unit area above 20mg per square centimetre. A more sensitive version of the gauge, developed for tissue paper and thin plastic films, &c., is stated to be capable of detecting variations of ±0·02mg per square centimetre.

FURZEHILL LABORATORIES, LTD.

The exhibits shown by Furzehill Laboratories, Ltd., Boreham Wood, Herts, were arranged to demonstrate some of the theoretical and practical aspects of servo-mechanisms and their application.

One demonstration of industrial motor speed control was based on equipment using a closed

loop servo-system to control the speed of a conventional three-phase induction motor. The equipment is designed for use with machine tools and continuous processing plant. A variable resistance in the rotor circuit is adjusted automatically by an auxiliary position servo-system to make the rotor resistance proportional to the slip. This condition causes the torque to be constant throughout the speed range. Magnetic amplifiers provide the necessary power amplification. With this system of control the speed can be varied over a wide range and it is possible to vary the gain and other parameters in such a way as to make the speed regulation and response rate adjustable to suit the operating conditions.

To demonstrate the performance of the control system a reaction dynamometer was coupled to a 2½ h.p. motor to serve as a mechanical load, while the control equipment itself was housed in a separate metal cabinet.

Electronic Instruments, Ltd.

The vibrating reed electrometer (model 32) which was exhibited by Electronic Instruments, Ltd., is designed to measure currents as small as 10^{-16}A. The new instrument (Fig. 11) is a direct commercial development of the type "1086A" electrometer designed by the Atomic Energy Research Establishment, Harwell. As illustrated the apparatus consists of two units—a vibrating reed converter unit complete with a pre-amplifier, followed by a measuring instrument which contains the main amplifier and indicator.

It may be recalled that the principle of the vibrating reed electrometer consists of converting the d.c. input signal into alternating current by applying it across a condenser of high insulation, one plate of which is maintained in constant vibration at resonant frequency. Subsequently the signal is passed to an a.c. amplifier and, after being reconverted into direct current by a phase-sensitive rectifier, it appears as a voltage on a direct-reading meter. A very high order of sensitivity is claimed for this arrangement, the zero drift depending entirely upon the contact potential of the vibrating reed unit; the makers state that, in general, the zero drift will not exceed ±100 microvolts in twenty-four hours, the short term stability being considerably better.

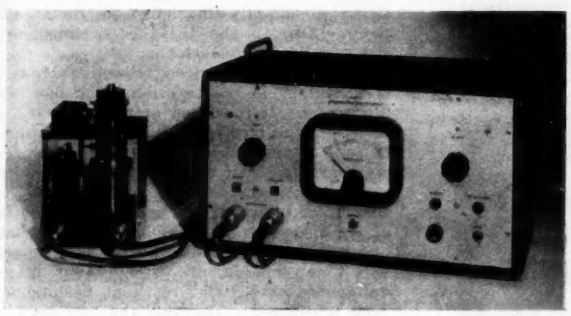


FIG. 11—VIBRATING REED ELECTROMETER—ELECTRONIC INSTRUMENTS

There are three voltage ranges giving full-scale readings of 1mV, 10mV and 100mV. A fourth range giving a full-scale deflection of 1V can be obtained by shunting the meter. On all ranges the accuracy is said to be better than ±1 per cent. The input resistance of the vibrating reed unit is greater than 10^{16} ohms and the background current does not exceed 5×10^{-17}A.

In operation the instrument must be switched on for some considerable time before precise measurements are taken, and in general it should be left running continuously to enable it to settle down to its most stable operating conditions.

When measuring ionisation currents a special ionisation chamber is provided which screws directly to the input terminal on the vibrating reed unit. Connection between the ionisation chamber and the vibrating reed unit can, however, be made by cable provided suitable precautions are taken. There are two methods of using the instrument for measuring small currents: either by observing the rate of charge of a condenser or by measuring the potential difference developed across a high resistance. In the consenser method, the incoming current is made to charge a built-in condenser and by noting the reading of the millivoltmeter after a given time the current may be found from the equation $I=CV/T$. In the resistor method, a resistor having a value up to 10^{12} ohms is connected aross the input terminals and the potential difference developed across it is read directly on the meter. It should be borne in mind that the accuracy of the measurement will depend upon the stability of the resistor which may vary between 1 and 20 per cent under laboratory conditions and should be carefully checked beforehand. Provision is made for connecting a recorder or an external meter to the measuring unit and a socket is available for injecting a calibration voltage from a standard potentiometer.

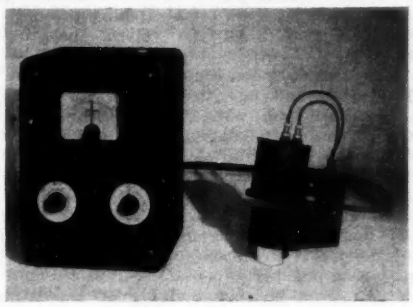


FIG. 12—"BETARAY" THICKNESS GAUGE—ELECTRONIC INSTRUMENTS

The same company also exhibited its "Betaray" thickness gauge which has been developed for general industrial use and can be used for continuously gauging thin sheets of most metallic or non-metallic materials during manufacturing processes.

The instrument depends upon the absorption of beta radiation by the instrument under test. In practice the sample is interposed between a radio-active isotope and an ionisation chamber. The isotope emits beta particles only, and when they penetrate the ionisation chamber a small direct current is produced which is then amplified by the measuring instrument. If a thin sheet of material is introduced between the isotope and the ionisation chamber some of the beta particles are absorbed by the material with a consequent reduction in the ionisation current. The current produced in the ionisation chamber is inversely proportional to the weight per unit area of the material; the gauge can therefore be calibrated to indicate weight directly or, if preferred, the calibration can be in thickness for any given material.

The gauge consists of a detector head (a robustly designed light alloy casting) connected by 10ft of armoured flexible tubing to a measuring instrument. The radio-active isotope is contained in one half of the detector head while the other half contains the ionisation chamber. The detector head is mounted on the mill in such a manner that the material to be gauged passes freely through the air gap between the isotope and the ionisation chamber. The measuring unit is usually placed alongside the mill where the meter indications may clearly be seen by the operator.

The controls are simple. A 4in meter mounted on the front panel carries two scales, a weight scale calibrated from 0 mg to 200 mg per square centimetre, and a deviation scale having a centre zero with graduations on either side. On the right of the panel is the "set zero" control and immediately below it is a scale graduated directly in thickness of any desired material. On the opposite side of the panel is the sensitivity control. A change-over switch is situated at the bottom of the panel in line with a socket for connection to an external recorder. The change-over switch allows the instrument to be used in either of two ways: the first is to give direct indication of the weight of any material; the second is as a limit gauge to control deviations in thickness during the manufacturing process. The general appearance of an earlier form of "Betaray" thickness gauge is shown in Fig. 12.

The range and sensitivity of the thickness gauge depend upon the isotope used. In general isotopes having the highest activity—and, hence, penetrating greater thicknesses of material—have a correspondingly shorter life and the most suitable isotope for thickness gauging at present available from the atomic pile at Harwell is a radio-active thallium salt which has a useful life of about three years and a reasonably high intensity of radiation. Using the thallium source, the range of the gauge is approximately 0 mg to 200 mg per square centimetre. It is a simple matter to calculate the equivalent thickness which can be gauged by the instrument for any given material, provided the density is known. Thus the upper limit for aluminium is approximately 0·025in, for paper 0·085in, while for steel, copper and brass the maximum thickness that can be gauged is of the order of 0·010in.

Nash and Thompson, Ltd.

A high-pressure recorder designed to make a simultaneous record of four pressures, each up to 1000 lb per square inch, was one of the exhibits shown by Nash and Thompson, Ltd., Oakcroft Road, Tolworth, Surrey.

This instrument is a mechanical recorder in which the pressures to be measured are communicated separately to four piston-operated indicators. The restoring force on each piston is provided by spring under compression and the resultant piston movements are recorded on a continuous 8in chart wrapped round a drum. Each piston has a radial clearance in its cylinder of not more than 0·0004in, and the total stroke of 0·4in is magnified by mechanical linkage to produce a pen stroke of 3in. The indicators are mounted in pairs on both sides of the recording drum and there is a vertical separation of 3½in between the zero lines of each pair of pens. A time base of one second is provided by a fifth pen, which is driven by a governed clockwork motor. Abrasive recording paper is used and its speed can be varied between ¼in and 1in per second. The instrument is designed for use with a 24V direct current, and there is provision for remote operation. Springs for various ratings up to 1000 lb per square inch can be supplied to order.

Another instrument shown on the same stand is a "glossmeter," which is being made by Nash and Thompson, Ltd., to a design of the Paint Research Station for giving a measure of the gloss of paintwork. In this instrument a parallel beam of light from a 6V bulb impinges on the test surface at 45 deg. and the reflected light is picked up by two selenium photocells. One of these cells receives the specular reflection from the test surface, while the other cell receives light reflected normally by the surface. The two cells are connected, in opposition, to a galvanometer, and there is an attenuator in the circuit of the cell that is specularly illuminated.

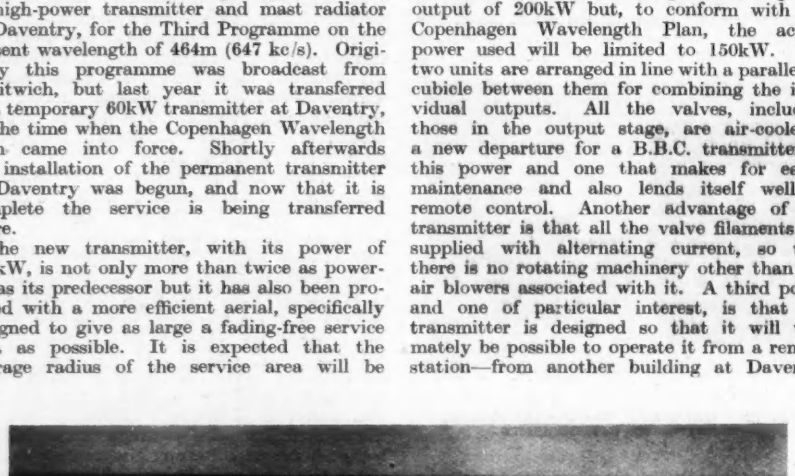
In use the instrument is placed on a matt surface and the attenuator is adjusted to give zero galvanometer reading. With this setting the instrument reading should be virtually zero on all matt surfaces. Then the instrument is placed on a surface of standard reflectance (black glass) and the galvanometer sensitivity is increased to give full-scale deflection. Readings can then be taken on test samples. A plate of heat-absorbing glass is included in the optical system and colour filters can, if required, be introduced into the beam.

(To be continued)

Third Programme Transmitter at Daventry

THIS week marks the opening of a new high-power transmitter and mast radiator at Daventry, for the Third Programme on the present wavelength of 464m (647 kc/s). Originally this programme was broadcast from Droitwich, but last year it was transferred to a temporary 60kW transmitter at Daventry, at the time when the Copenhagen Wavelength Plan came into force. Shortly afterwards the installation of the permanent transmitter at Daventry was begun, and now that it is complete the service is being transferred there.

The new transmitter, with its power of 150kW, is not only more than twice as powerful as its predecessor but it has also been provided with a more efficient aerial, specifically designed to give as large a fading-free service area as possible. It is expected that the average radius of the service area will be about 100 miles—towards the north and east it will be rather more—and that the number of listeners able to receive the Third Programme will be increased to about 70 per cent of the population.



CONTROL DESK OF HIGH POWER TRANSMITTER AT DAVENTRY

Daventry has the longest history of any B.B.C. transmitting station. Just over twenty-five years ago (in 1925) the B.B.C.'s first high-power transmitter for long-wave broadcasting—Daventry 5XX—was installed there, to be followed two years later by the high-power medium-wave transmitter 5GB. In 1932 the station was rechristened the Daventry Empire Station, after the installation of the transmitters for broadcasting to the Empire on short waves. By 1937 the number of short-wave transmitters had increased to six, with a further increase to eleven by 1940, making Daventry at that time the B.B.C.'s most powerful short-wave broadcasting station. Meanwhile, the long and medium wave services had been transferred to new and more powerful transmitters at Droitwich.

The new Third Programme transmitter, which has been designed and manufactured by Marconi's Wireless Telegraph Company, Ltd., is in the building that originally housed the 5XX transmitter. It consists of two identical transmitter units, which can work in parallel, each complete in itself and each capable of an unmodulated carrier output power of 100kW. Thus, the transmitter is capable of a power output of 200kW but, to conform with the Copenhagen Wavelength Plan, the actual power used will be limited to 150kW. The two units are arranged in line with a paralleling cubicle between them for combining the individual outputs. All the valves, including those in the output stage, are air-cooled—a new departure for a B.B.C. transmitter of this power and one that makes for easier maintenance and also lends itself well to remote control. Another advantage of the transmitter is that all the valve filaments are supplied with alternating current, so that there is no rotating machinery other than the air blowers associated with it. A third point, and one of particular interest, is that the transmitter is designed so that it will ultimately be possible to operate it from a remote station—from another building at Daventry or from Broadcasting House, London, for example—by means of signals sent over a single telephone channel. The B.B.C. has had low-power remotely controlled transmitters in service for some time, but this is the first time that an attempt has been made to apply remote control to one of its high-power transmitters.

The output from the final amplifier in each of the 100kW units is taken to the combining cubicle, which is in the centre of the transmitter, between the two units. By means of contactors in the cubicle, which are remotely controlled from the front of the transmitter or from the control desk, either of the units can be connected to the outgoing feeder, or they can be combined in parallel. Alternatively, each unit can be connected to a water-cooled test load.

The high-voltage d.c. supply at 12kV for the modulator and modulated amplifier is obtained from six single-anode mercury-arc rectifier valves in a full-wave three-phase circuit. Besides being more compact, this system has the advantage over the multi-anode type of rectifier that an ordinary high-voltage transformer can be used. The auxiliary power supplies are conventional. Each 100kW unit is supplied with about 12,000 cubic feet of air per minute for cooling the valves. The air enters the transmitter through ducts at the top, flows over the valves and is extracted through another series of ducts underneath the floor. During cold weather some of the exhaust air can be discharged into the transmitter hall to warm it.

Facing the transmitter is a control kiosk, having windows along the front, as illustrated herewith, so that the engineer on duty (if the transmitter should be operated manually) can see the transmitter. The kiosk contains a control desk, consisting of three panels, carrying the controls and meters for operating and monitoring the transmitter. Two of the panels are associated with the two 100kW units and on the third are the remote controls and indicators for the combining circuits. A remote-control system at present under examination enables either transmitter unit to be powered and its output connected to the feeder or to the test load. Alternatively, both units can be powered and operated in parallel, provided that the phasing has been set correctly at Daventry. Once the transmitter is operating the line between it and the remote control point is no longer needed to keep it operating and so can be used for telephone communication or for low-quality monitoring. In addition, signals are sent back over the line to the remote control point to show the state of the transmitter. A watch is kept on the performance of the remote-control system by sending a tone continuously through the remote terminal equipment, up the line, through the terminal equipment at Daventry and back down the line again.

Mast Radiator

About a mile and a quarter to the east of the transmitter building, on a site 460ft above sea level, a mast radiator has been erected to serve as an aerial for the new transmitter. It is 725ft high and is the tallest mast yet employed by the B.B.C. for a medium-wave transmitter. It was designed and erected by British Insulated Callender's Construction Company, Ltd., to the B.B.C.'s specification of structural requirements.

The mast is of lattice-steel construction and is triangular in cross-section, each face being 9ft across. It is stayed at three points only, at heights of 210ft, 420ft and 640ft approximately above the ground. Three pairs of stays are attached at each of these levels and each stay is broken up by insulators into lengths of between 70ft and 100ft. The base of the mast is poised on an insulator shaped like two truncated cones placed apex to apex, which is capable of withstanding a peak voltage of over 100kV without flashing over, even when wet. Between the two halves of the insulator is a ball joint, which permits the mast to deflect several degrees from the vertical. The dead weight of the mast is about 60 tons, but when it and the stays are covered with ice and subjected to high winds, the maximum load on the foundation is nearly 250 tons. To avoid an excessive weight of steel being used, the main leg angles are fabricated of high-tensile steel.

At a point 460ft above the base, the mast is divided into two sections by an insulator similar to the one at the base. Thus, the lower section extends up to a height of 460ft then comes the insulator at the "nodal" point and above that is the top section, extending up another 265ft. At the mast-head there is a capacity top consisting of a number of spokes projecting out to a distance of 35ft, with their extremities connected together by wires. The spokes are hinged close to the mast so that they can be folded down if the capacity top is not required.

An interesting point about this mast radiator is that the radio-frequency power is fed into it across the insulator at the 460ft level instead of at the base. This method has been adopted in order to reduce fading by minimising the effect of the feed current, which, with a conventional base feed, distorts the vertical polar diagram by increasing the high-angle radiation.

The power from the aerial tuning circuits at the base is fed into the mast at the 460ft level through an unbalanced open-wire transmission line, which is fixed inside the mast.

The inner conductor of this transmission line consists of four steel-cored aluminium wires disposed round a circle having a diameter of 8in and tensioned by bottle screws. Eight similar wires on a pitch circle of diameter 2ft form the outer conductor. The inner wires are located by insulated cross-pieces spaced at 20ft intervals, and the outer wires are bonded to the mast steelwork at similar intervals. In addition to the main feed at the 460ft level, the base of the mast is connected to circuits in the aerial tuning house, which enable some variation of the current distribution on the lower section to be made.

Aircraft warning lanterns are fixed to the mast at the top and also at the heights of 150ft, 290ft, 440ft and 580ft. Except at the top, the lanterns are mounted in pairs and are fed through separate mineral insulated cables, so that if one circuit fails there will still be a lantern alight at each level. From the mast-head and also from the insulator level there are telephone lines for communication with the ground. The cables for the lanterns and telephones are carried past the insulator at the 460ft level by enclosing them inside an inductance coil, which is connected across the insulator.

On the lower section of the mast four pick-up loops, each with a crystal rectifier, have been provided, the crystal outputs being connected to meters in the aerial transformer house. By this means the current distribution on the lower mast section can be determined.

The earth system consists of a 90ft square screen of wires and a spider's web of wires radiating out to a distance of 750ft at 5 deg. intervals and buried 9in underground. The transmitter output is connected to the aerial tuning house at the base of the mast by a twelve-wire unbalanced open-wire transmission line supported on steel poles 18ft high and spaced at 150ft intervals. The outer conductor of the line is formed by eight wires on a pitch circle having a diameter of 1ft 6in and the inner by four wires on a circle of ½in diameter. The length of the feeder is 2640 yards, and the loss is approximately 0·35 db. The aerial tuning house contains two sets of equipment for coupling the aerial to the feeder line, one set being for normal use and the other for standby. When the standby set is in use the mast is fed at the base and the transmission line from the top section is terminated by a network, which reduces the reactance across the break-insulator so that the mast behaves like a conventional series loaded mast radiator. The normal and standby sets of coupling equipment are connected to the mast and to the twelve-wire transmission line through switches which are remotely operated from the transmitter building. Thus, either set can be brought into circuit without an engineer having to make the long journey out to the aerial from the main building. The aerial tuning house is thoroughly screened by copper sheet and gauze on the inside and by wire netting on the outside.

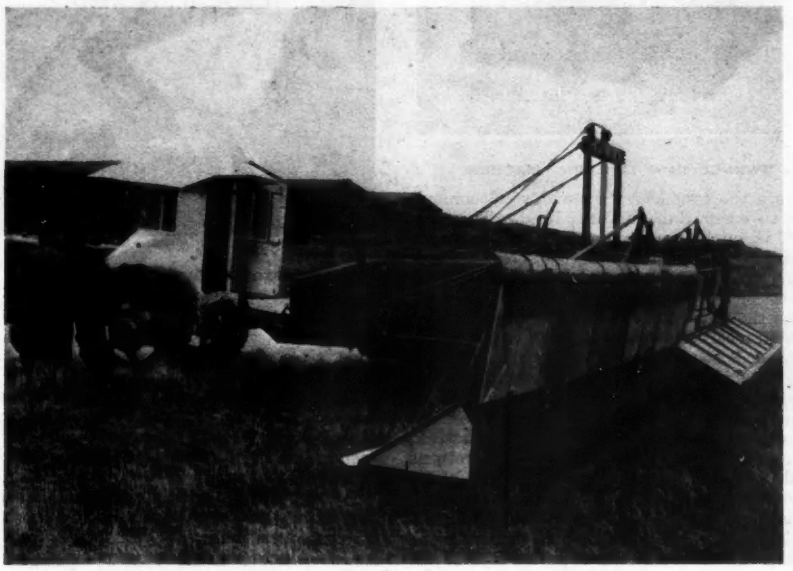
Safety Devices for Crop Spraying Equipment

IN any assessment of the progress made in agricultural and horticultural practice during the last decade, consideration must be given to the spraying of many kinds of crops in order to control insect pests and weed growth. Not only have there been advances in the chemicals used, but there has also been rapid development of the machinery by which these chemicals are applied to the land or to growing crops. As with most technical progress, however, there have been problems which have demanded solution before it could be said that perfection in the art of crop spraying was being approached. One of these problems is the damage caused by the drift of weed killers and insecticides on to neighbouring susceptible crops. In this country, for instance, sugar beet fields have suffered and damage has also been caused to other crops, such as cabbages. Furthermore, it has been discovered that small quantities of plant hormone weed killers can do much harm in a hop garden. In overseas countries, plant hormones sprayed for controlling weeds in rice crops have drifted across to cotton plantations, thereby causing considerable damage.

A British organisation which has given close attention to the problem of drift in crop spraying is Pest Control, Ltd., Harston, Cambridge. The company produces spray chemicals and machinery for their distribution, and also carries out spraying operations on a contract basis. Under the guidance of its managing director, Dr. W. E. Ripper, this company has devised methods for drift prevention and last week it demonstrated, in the field, the equipment now being fitted to the spraying machines which it employs on its contracting work. A device known as the "Nodrif" boom is being used on the company's standard "Cambridge" sprayers, which have a spray bar 40ft wide and there is an arrangement which enables the height of the spray bar to be accurately adjusted. The spray bar consists of three sections, each of which has its individual cowl. In the accompanying illustration, one section of the cowling is shown in the raised position to indicate the nozzles on the spray bar. Both the side booms are supported by castor wheels, which keep the spray bar at a constant distance from the ground and also prevent the wind shields from digging into the ground. The wind shields themselves are arranged to form a large obtuse angle with the field, so that the wind may be more easily deflected over them. To guard against side winds, folding triangular deflectors have been provided and there is a serrated rubber curtain along the lower edges of the deflectors, which is an additional aid in preventing wind from getting underneath the shield. The firm claims that tests which have been made have shown that from 53 to 100 per cent of the spray drift can be prevented by the "Nodrif" boom, and that, at a wind velocity above 12 miles an hour, 18 to 28 per cent of the spray is blown away when an ordinary spray boom is used.

Apart, however, from the prevention of the drift which can damage adjacent crops and, if toxic chemicals are being used, can be injurious to passers-by on public highways, consideration must also be given to the effect of the drift on the operators of spraying equipment. A working party set up by the Ministry of Agriculture a year ago, under the chairmanship of Professor S. Zuckerman, F.R.S., was invited to make recommendations for the promotion of the safety of workers using toxic substances in agriculture. It has already put forward suggestions about protective clothing and decontamination arrangements.

Pest Control, Ltd., claims that additional protection is given by the use of its "Nodrif" boom as it helps to ensure that operators are not smothered by the chemical when spraying operations in wind are carried out. But the firm has also made improvements in the gas-proof air-conditioned tractor cabs which it produces for its contracting plant. The improved cab, which is shown in our illustration, is an almost air-tight cabin, into which air is passed through a compressor driven from the power take-off of the tractor. On the intake side of the compressor there is a large charcoal filter which absorbs gases and in front of it is a filter for collecting fine smoke and dusts. A pressure, rather higher than the atmospheric pressure, is maintained, and the air escapes through the gaps in the cab structure through which the tractor controls pass. As will be noted in the illustration, a parasol-like sun screen has been fitted over the cab so that a large part of the glass side-panels is shaded from the sun. The working party, referred to earlier, stipulated that spraying operations should cease if the temperature rose above 80 deg. Fah., and Pest Control, Ltd., has therefore now arranged its air-conditioned cabs in such a way that the temperature is kept below 75 deg. Fah. This is effected by heat insulation and by trickling water over the cab —a method often used in greenhouses in tropical countries. The spraying machine has to be frequently refilled with water and it is therefore a simple matter to refill the tank on the air-conditioned cab at the same time. As soon as the thermometer inside the cab registers a temperature above 70 deg. Fah., the operator turns on a tap, which sets the water cooling device in action.

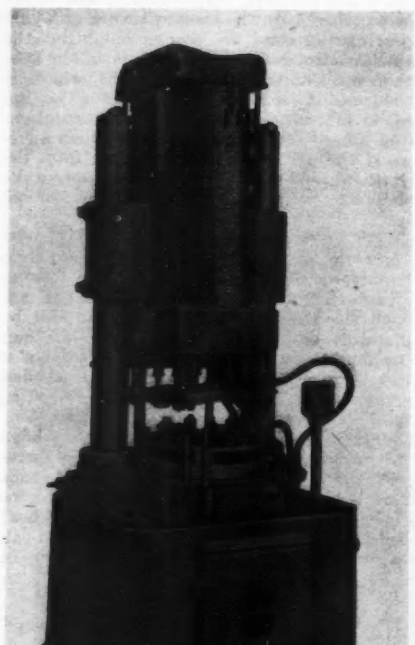


SPRAYER FITTED WITH COWLED BOOM

A Twin-Column Drilling Machine

A TWIN-COLUMN drilling machine with an automatic cam feed unit head and an indexing table, recently designed and built by Adcock and Shipley, Ltd., of Leicester, is illustrated in the accompanying engraving. This machine is suitable for use with a driving motor of up to 20 h.p. and has a 22in diameter indexing table. It was built by the company following very successful working with a batch of smaller 2 h.p. machines with 15in diameter indexing tables.

The twin-column construction of these drilling machines ensures that the thrust from the tools is taken close to the point of support, and they can be used for a wide variety of work. The box cabinet base encloses the table indexing mechanism. and flanges on the base



TWIN-COLUMN DRILLING MACHINE

support the two heavy ground steel columns used to carry the unit drill head. This drill head, through screw and nut mechanism, can be adjusted vertically on the columns and means are provided to clamp the head rigidly in position. A foot-mounted motor in the head drives the main spindle through vee belts and the feed mechanism through suitable gearing.

The drill head is totally enclosed and moves in long slides, its weight being adequately counterbalanced. A hardened barrel cam which, through a roller, operates the feed movement in the head, gives a quick approach to the work, changes to drilling feed rate and rapidly returns the drill head at the end of the operation.

Normally the machine's indexing table is operated by a Geneva movement, in which an accelerating mechanism is incorporated to shorten the time of the indexing cycle. If automatic indexing is not necessary for the class of work a hand indexing table can be fitted. A locating plunger is used to ensure the accurate location of the indexing table and is interlocked to provide that it is fully home before the drill head begins to feed down.

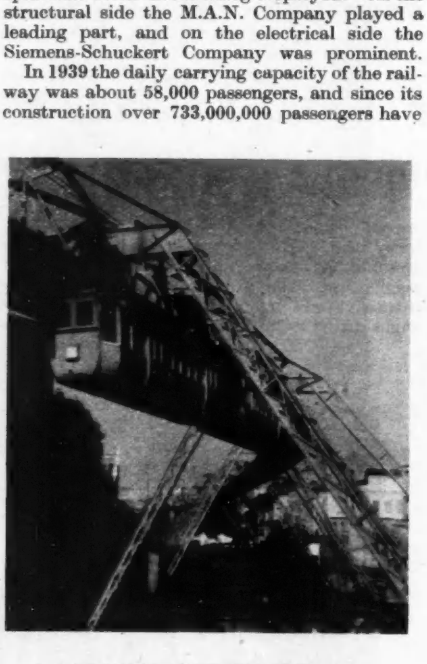
The machine illustrated is fitted with a six-station hand-operated indexing table, and its five machining stations are laid out for the following operations on a gear—rough end mill two 0·385in radii; finish end mill the two radii; drill two $^{39}/_{64}$in holes; ream two $\frac{3}{8}$in. holes; and chamfer the holes.

Jubilee of the Wuppertal Overhead Railway

DURING a recent visit to Germany we were invited by the Wuppertal Stadtwerken A.G. to visit the famous overhead railway known as the "Schwebebahn," which, on March 1st last, celebrated its fiftieth year of operation. This railway connects the towns of Oberbarmen, Barmen, Elberfeld and Vohwinkel. It has a total length of 13·3km of double track, of which 10km are over the River Wupper and the remaining 3·3km over the main street between Sonnborn and Vohwinkel. For the street section a special portal girder of circular form is employed, while the accompanying illustration shows the structure employed over the river Wupper. The girders are spaced at 30m intervals, with splayed supporting girders at 200m to 300m intervals, and there are eighteen stations, with an average distance between them of about 775m.

To meet varying conditions of loading, in the busiest periods trains travel at 3 min. or 2½ min. intervals, while in the slacker periods intervals between trains may be as long as 12 min. The maximum speed was originally fixed at 60km per hour, but at present a maximum speed of about 40km per hour is used. During its fifty years five different classes of cars have been used and are still in use. They differ in detail as regards the motor drives and springing, both spur and worm drives being employed. On the structural side the M.A.N. Company played a leading part, and on the electrical side the Siemens-Schuckert Company was prominent.

In 1939 the daily carrying capacity of the railway was about 58,000 passengers, and since its construction over 733,000,000 passengers have



WUPPERTAL OVERHEAD RAILWAY

been carried. The damage sustained in the war period put it out of operation for some time, but full working was restored at Easter, 1946.

The railway owes its being to its inventor, Eugen Langen, of Cologne, who worked with Otto on the four-stroke gas engine at the Gasmotoren Fabrik Otto and Langen. Its construction was started in 1898, and on March 1, 1901, the first 4·5km between Elberfeld Zoological Gardens was put in operation. Three months later the 3km length from the Zoo Station to Vohwinkel was finished, and in 1903 the eastern section to Oberbarmen was completed. In a recent issue (March 1, 1951) *Zeitschrift des Vereines Deutscher Ingenieur* published five articles on the Wuppertaler Schwebebahn. They include an article by Obering Dip-Ing. O. Bucholtz on "Early History and Importance"; by Obering Dip-Ing. L. Ackermann dealing with the structural side, Ing. W. Merkel, V.D.I., with the carriage design and construction; and Obering Reg-Baumeister H. Merkel with the signalling, safety devices, carriage sheds and repair shops. Of more general interest is the book "Die Schwebebahn," by Dr. Kurt Hackenberg, recently published on behalf of the Wuppertaler Stadtwerke A.G. by the Rheinische Bücherei, of Ratingen and Wuppertal.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24 Victoria Street, London, S.W.1.

STEELS FOR CHEMICAL, PETROLEUM AND ALLIED INDUSTRIES

No. 1501–1506 : 1950. This new publication, covering a series of steels, forms part of a comprehensive scheme of standards for pressure vessels for use in the chemical and allied industries. The publication covers four separate standards, which deal with Plates, Bars and Sections (11 specifications), Forgings (11 specifications), Castings (12 specifications), Bars for Bolting Material (16 specifications).

This series of steels forms a complement to B.S. 1500, Code for Fusion Welded Pressure Vessels, and provides a range of materials for use in the construction of vessels to that code. Recommended stresses for the steels, together with an indication of the temperature range within which they may safely be used, are given in B.S. 1500.

As further steels will be added to the series, it was felt that a rational system of numbering should be adopted to indicate the type of steel, irrespective of the form. Appendix B explains in detail the system adopted and indicates the basis on which it has been built.

In providing a comprehensive series of all steels used in pressure vessel construction, certain steels already covered by existing British Standards have been included, and Appendix C indicates any existing British Standards which are similar to those included in this series. The opportunity has been taken to indicate the nearest equivalent American steel in either the A.S.T.M. or the A.I.S.I. series. Price 12s. 6d.

METHODS OF TESTING VULCANISED RUBBER

No. 903 : 1950. The first edition of this specification was issued in 1940, and this revision provides standardised methods of analysis and tests for vulcanised rubber, both for the purpose of providing methods for use in British Standards and to provide a set of reliable methods for use by all those concerned with the analysis and testing of vulcanised rubber. In addition to a great number of tests which are now in general use having been added to the original standard, the scope has been widened to cover synthetic rubbers as well as natural rubber. It is, however, not implied that every test described is appropriate or suitable for all types of vulcanizate.

It is pointed out that the standard does not include all the test procedures for which standardisation is desirable, because some require further investigation before reliable standard techniques can be recommended. In view, however, of the urgent need for a revised standard to meet the demands of rubber manufacturers and users, it has been thought best to defer inclusion of these still debatable procedures until they have been further studied.

The contents have been arranged in such a way that closely related methods are grouped into a self-contained document and are given a distinctive number. The various methods of analysis and tests covered by the standard are as follows:—Acetone extract, unsaponifiable matter in acetone extract, paraffin wax and ceresin, chloroform extract, alcoholic-potash extract, total sulphur, extractable sulphur, rubber-combined sulphur, sulphur in total fillers, sulphide sulphur, natural rubber hydrocarbon (direct determination), nitrogen (for acrylonitrile polymers), chlorine (for chloroprene polymers and copolymers), isobutene-diene (butyl rubber), thioplast rubbers, total fillers, ash, carbon black, antimony, copper manganese, carbonate, glue, cellulose, water extract.

A wide range of methods for physical testing are included. Price 21/-

FORGED STEEL SOCKET-WELDING FITTINGS FOR THE PETROLEUM INDUSTRY

No. 1684 : 1950. This specification is based on two American specifications, A.S.A. B16 : 11 and A.S.T.M. A234. It gives details of the sizes, materials, body thicknesses, tolerances, tests and marking, together with tables giving the full details of all the necessary dimensions required for socket welding, elbows, tees, crosses, 45 deg. elbows, couplings and caps. Price 3s.

Riveted and Welded Joints

THE following two papers were presented at a meeting of the Applied Mechanics Group of the Institution of Mechanical Engineers last Friday, April 6th. We print a short abstract from the first and the author's summary of the second.

LOAD DISTRIBUTION IN RIVETED AND SPOT-WELDED JOINTS

By D. WILLIAMS, D.Sc., M.I.Mech.E.*

It is generally accepted that the relative behaviour of riveted and spot-welded structures is governed not only by the relative failing strengths of the individual rivet and spot weld, but also by the fact that the spot weld provides a much more rigid connection between two sheets than the rivet. Whereas a severely stressed rivet tends, by its own deformation, to relieve itself of load by sharing it more equally with its neighbours, a spot weld has not the same facility for "giving" under strain, and therefore tends to cling to its load until it fails. That this view is sound was recently demonstrated by the rather striking difference in the failing loads of two tapered box beams under bending loads, one riveted and the other spot welded. The construction of the two box beams was the same, and the number and disposition of the spot welds were identical with those of the rivets; yet although the individual spot welds, as shown by later tests, had nearly twice the failing strength of the individual rivet, the spot-welded box failed at a load of only two-thirds that of the riveted box. The type of failure, however, was the same for the two, namely, a shear failure of a whole row of rivets and spot welds over the outermost 2ft of the spar flange.

The purpose of this paper is to examine, on the basis of certain experimentally obtained shear-deflection curves for rivets and spot welds, the load distribution for the two types of fastening, both at low loads, when the shear-deflection curves are still substantially linear, and at higher loads well above the yield point, particular note being made of the structure load at which the yield point of rivet or spot weld is first reached and of the load at which failure occurs. This can only be done by confining attention to certain simplified types of structures. Even so, a study of a few simple cases is well worth while in that it enables the designer to gain the insight necessary for estimating what takes place in more complicated cases. It is emphasised, however, that, although somewhat simplified, the cases considered are otherwise fairly representative of current practice.

CONCLUSIONS

The following general conclusions may be drawn from the above discussion of the two simple types of riveted and spot-welded structures chosen for analysis.

(1) *General Behaviour.*—The shear distribution in rivets and spot welds depends upon two factors—their own stiffness in shear, and the effective area of the members they connect. Below the yield point of the rivets there is little difference between the stiffness of the two fastenings, and the shear distribution curves are much the same for both, whether the members to be connected are thin, as in the lap joint, or stout as in the reinforced panel. Before the welds are halfway to their yield point the rivets begin to yield and the increase of rivet load with deflection is thereafter so small that the shear per yielded rivet is practically constant as shown in curve B of Fig. 3 and A_1 of Fig. 8, and by the time the end welds reach their yield point, the rivet construction is taking the same load quite comfortably at a peak rivet load about half the peak weld load.

As the load is still further increased the end welds enter their plastic range while the rivets enter further into theirs. Owing, however, to the limited "plastic" deflection of the welds compared with that of the rivets, the latter are still holding on when the end weld reaches breaking point.

(2) *Shear-Lag Cases.*—In shear-lag cases—that is, cases where the shear flexibility of sheet panels is an important factor in the distribution of load, the shear flexibilities of the rivets below yield and of the welds up to failure are largely masked by the sheet flexibility. The rivets above yield, however, have a shear flexibility comparable with that of the sheet, and this has an important effect in producing a more even distribution of load among the rivets, as shown by curve A_1 of Fig. 8 in contrast with curve B.

(3) *Sheet Stresses.*—In both the cases examined the rivet construction gives a slightly higher failing load (judged on the strength of the fastenings rather than on the members connected) than the welded construction. It is important, however, to examine the difference in the manner in which that higher load is reached, and particularly the effect of that difference on the sheet. It is clear from the curves that the rivets at high loads distribute the shear much more evenly along the sheet than the welds, which makes for greater sheet strength if it is accepted that strength depends upon the load transmitted by a fastening as well as on the tensile stress in the unbroken sheet.

(4) *Strength Under Repeated Loading.*—From an aeronautical aspect, strength under repeated loading is important and it is generally accepted that the danger to an aeroplane lies more in the frequent application of loads of 10 to 20 per cent of its static failing load than the much less frequent application of higher loads of 50 per cent and above.

In the case of the lap joint loaded to, say, 60 per cent of a reasonable design failing load (30,000 lb per square inch in the unbroken sheet) the most highly stressed rivet is at yield point while the corresponding weld is at 50 per cent yield, although the shear is practically the same for each. The sheet therefore is under much the same condition in each case, but the weld seems better off than the rivet. Moreover, at lower lap-joint loads than 60 per cent, the rivet load, while approximately equal in absolute value, is still twice that of the weld, in terms of yield load.

Thus, as regards the fastenings themselves, repeated low loads have probably a greater deleterious effect on the rivets than on the welds, but as regards the sheet the loads applied by each type is the same for the same sheet loading, and any difference in the fatigue behaviour of the sheet can only be attributed to the difference in the manner in which a spot weld compared with a rivet transmits its load.

In the shear-lag case considered the applied load needs to be less than one-third of the design failing load (15 tons per square inch in the booms) before rivet and weld shear distributions are approximately equal. For higher loads, whereas the end welds reach their yield points only at 75 per cent of the design load, more and more of the rivets enter the plastic region after the initial yield at about 30 per cent. In view of the rarity with which an aeronautical structure is loaded beyond that percentage of its ultimate strength, this behaviour of the rivets at the higher loads may not be as important as it might appear.

(5) *Different Design Approach for Riveted and Welded Structures.*—Clearly the character of the loads to which a structure is likely to be subjected, determining as it does the relative importance of ability to reach a high static failing load and capacity to withstand the constant repetitions of smaller loads, must be considered in the choice between a riveted and spot-welded structure. Whereas the simple structures considered here have been compared on the basis of the same number and location for rivets as for welds, a rational design would have to be based on a full recognition of the essential differences of their characteristics.

* Senior Principal Scientific Officer, Ministry of Supply.

DESIGN STRESSES IN FILLET WELD CONNECTIONS

By F. KOENIGSBERGER, M.I.Mech.E.†

Intuition and personal opinion, rather than theoretical investigation, have often been the main guides in the determination of design stresses for fillet weld connections. Excessive safety at the expense of accuracy and economy have resulted in weld connections, which, although they did not fail under working conditions, were not always economical.

In the case of eccentrically loaded joints the stress $f_{TORSION}$ under a torque T has been determined by using the polar moment of inertia J of the weld throats: $f_{TORSION} = Tr/J$, where r is the distance of the extreme fibre from the centroid of the weld throat. This method, though accurate enough for closed weld arrangements, resulted in uneconomical sizes for other arrangements. This paper suggests a means of determining the working loads of eccentrically loaded fillet welded joints by working out the stresses in the plastic state prevailing immediately before failure occurs. From this calculation the value of the failing load is obtained, which is divided by a certain load factor, the result being taken as the permissible load. If the results are represented in the form of graphs the time spent on calculation is considerably reduced. Practical experiments gave results which were in close agreement with the result of these calculations.

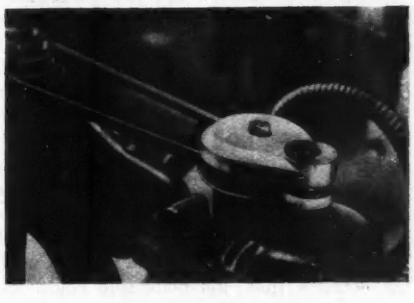
In the second part of the paper the two differing opinions on the best arrangement of fillet weld connections joining rolled angle sections to gusset plates are investigated, so far as their effect upon the strength of the assembly is concerned, and no difference is found with regard to the static strength of the assembly, while stress peaks at the end of the welds may indicate a weakness of one arrangement under fatigue loading conditions. Further research in this direction is suggested.

† Lecturer in charge of welding engineering in the Department of Mechanical Engineering, Manchester College of Technology.

A Small Reduction Gear

IN the photograph reproduced below can be seen a neat little gear reduction unit which is now being made by H. and J. Weymouth, of Godalming, Surrey, for use in connection with small electric motor drives. In the case illustrated it is fitted to the motor of a small drilling machine, but it can be adapted for a variety of other purposes where a reduction of 3½ to 1 is required, and in particular with standard ½ h.p., 1425 r.p.m. motors.

The unit consists essentially of a light alloy housing at one end of which is a ball-bearing



REDUCTION GEAR UNIT

mounted pinion which drives a gear wheel bolted to one flange of a vee-grooved pulley. The pinion is bored to take adaptor bushes made according to the size of the motor shaft to which the unit is to be fitted. The pulley and gear assembly is carried on an "Oilite" bush and rotates on a hardened and ground sleeve on the main central bolt which holds the unit together. A ½in vee belt can be driven from the standard 40 deg. grooved pulley, which is machined to an additional depth to take ⅝in belts if necessary.

We are informed that these reduction units are distributed through the maker's agent, F. W. Dummer, 196, Galpins Road, Thornton Heath, Surrey.

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A DISCOURAGING BUDGET

In preparing the Budget he presented to the House of Commons last Tuesday, Mr. Gaitskell had a particularly difficult task to perform. Undoubtedly he has made a courageous and honest attempt to solve his problems satisfactorily. But once it was assumed that economies in Government expenditure could not be made, the problems remained intractable. The measures proposed in the Budget will not only hurt those who will primarily have to pay for rearmament. They are also likely to do harm to the nation's economy. In preparing his Budget Mr. Gaitskell was faced by the difficulty that the diversion of productive capacity from the making of consumer goods to the manufacture of armaments must necessarily reduce the quantity of consumer goods reaching the home market. But the total of expendable incomes would not be reduced by that diversion. He had therefore to decide whether to let prices rise to fill this "inflationary gap," hoping meanwhile to prevent salary and wage increases; or whether, economy in Government expenditure being regarded as impracticable, to increase taxation to absorb the excess income. In the result, and wisely, he chose the latter course. For the former was hardly possible. In presenting the Budget he could foresee that he would have to warn the country that his budgeting could not protect the people from rising prices caused by increased costs of raw materials. To allow a further inflationary rise to occur upon the top of it would have made it impossible to believe that the appeal he directed to trades unions to exercise restraint in the placing of wage claims in the coming years could prove effective.

As foreshadowed by the Economic Survey for 1951, Mr. Gaitskell estimated the inflationary gap at £150 millions, the sum that had to be withdrawn by taxation from the pockets of the people. In deciding how to spread that taxation the Chancellor had to bear in mind that it should not discourage productivity, should not prove a disincentive to hard work and should not unduly interfere with the development of productive resources. The attempt has been honestly made to spread the burden equitably. The "gap," it is proposed, should be mainly closed by an increase of 6d. in the three rates of income tax. But that tax is already at a deplorably high level for peacetime; and though, as a result of increased allowances to married couples and for children, many wage-earners will be relieved of increased payments, the increase cannot but discourage further the inclination to work overtime and must thus act rather towards reducing than increasing productivity. It is proposed that the greater part of the remainder of the "gap" should be closed by the increase of the duties on fuel oils and petrol. There is, for Chancellors, invariably something attractive about taxing those essentials. The yield is large and the imposition of tax seems hardly to have any effect upon usage. Chancellors like to believe that the imposition of the tax does not lead to increased costs of road transport. But in fact, of course, in one way or another the increased cost of fuel has to be passed on. Indeed, the best justification for the tax is the fact that it is passed on, its effects being felt by the community at large, not only by transport operators. If that were all, the tax might seem a good one. But unfortunately, since transport costs enter into the costs of manufacturing almost everything, the tax necessarily increases manufacturing costs. Thus, besides increasing home prices, it also increases the prices of those exports that manufacturers are urged to sell abroad. The proposed increases in purchase tax on motor-cars and wireless sets, though lifting their prices to levels that could not be tolerable for long, are perhaps justifiable as a temporary expedient to reduce home demand upon industries likely to be called upon for armaments production. But the same approval cannot be given to the proposal to suspend the initial allowance of 40 per cent for income tax and profits tax on plant and machinery and 10 per cent on industrial buildings, &c. That, in combination with the increase in the tax on distributed profits, is a discouraging blow to industry at a time when it is attempting to re-equip itself for armaments production and for increased civil output and when, in particular, it is already hampered by the need to raise capital to carry stocks of raw materials at increased prices. As the Federation of British Industries has already commented, "The increase in income tax and the distributed profits tax will mean that the resources of industry will be further depleted at the very time when price levels call for increased working capital. . . . These measures can only operate to discourage capital development designed to promote production efficiency and further to lessen the attractiveness of risk-bearing capital, the provision of which is so essential to the long-term needs of industry."

For the rest Mr. Gaitskell's proposal to limit the cost of the Health Scheme by making charges for certain services is particularly courageous in a Socialist Chancellor, and the proposed changes in pension rates, which may well encourage the elderly to remain at work beyond the normal retiring age, are welcome when every extra productive hand can help to increase output and thus to relieve the strain on this nation's stretched economy. But, on the whole, the Budget seems to us to suffer the defect that it looks too much at the present and too little to the future. The wisdom of imposing new burdens upon industry, burdens that will hamper its expenditure upon new and more highly productive equipment, is particularly questionable. If greater, instead of less, expenditure in that field could be encouraged by less immediate expenditure upon social services, the benefit would the sooner be felt in the future by the ease with which the country would then be able to pay for social services on a scale even bigger than that now ruling. But it was too much to expect that the Chancellor would dare to move in that direction. Since he could not do that the problems he was called upon to solve have proved to be without satisfactory solutions.

EDUCATION OF THE EMINENT

Formal education for engineers, as for members of other professions, usually ends, at latest, in the early twenties. Thereafter they become free to follow their own inclinations untrammelled by the behests of examiners that certain subjects must be mastered, whatever else is not. A job is found, some facet of it intrigues them and—hey presto!—within a few years the more brilliant begin to attain to reputations for authoritative knowledge in that specialised subject. Thenceforth, if it can, the world grants them no relaxation. For authorities on abstruse subjects are far from numerous and everyone therefore refers problems to such few as there are. Their work never ends. Such men soon become eminent. Each bestrides the technical world like a Colossus. But lesser men who "peep about under his huge legs," fear that, for the specialist, deep study must "narrow the world to his neighbour's gate." They suppose, indeed, that an embryonic authority left to himself will soon be unable to talk of anything else or to think in any terms other than those of his special technology; nor to communicate coherently with any but other workers in his chosen field. As soon therefore as the

status of eminence is approached it is insisted by convention that a liberal education shall be begun anew. It is, of course, too much to expect that eminent men shall find time to go back to school. But that difficulty is quite simply overcome. For a man "may live without books—what is knowledge but grieving? He may live without hope—what is hope but deceiving? He may live without love—what is passion but pining? But where is the man who can live without dining?" It is merely necessary to insist that the eminent shall accept numerous invitations to dinners and to ensure, whether they wish it or not, that they are placed at the top table. For there, it is known, their minds must be broadened!

At our modern big and formal dinners lesser men are permitted to make up parties, to sit together amongst friends. But such a liberty must be denied to the eminent. It is for the organisers to arrange where they shall sit and who shall be placed next to them! Below the salt the specialist can be surrounded by his cronies and indulge comfortably in conversations confined to "shop." But that is a vice denied to the eminent. They must be made to relax; their minds must be broadened by the need to discuss topics of which they know nothing. The chief engineer of a Water Board, for example, must not be placed alongside a manufacturer of pumps or a well-known civil engineer. His companions should rather be the Ruritanian ambassador and one of the more outspoken of American Senators. The technologist of an atomic research establishment is considered appropriately placed if he separates the Poet Laureate from the Solicitor-General. And where should that industrial magnate, director of innumerable engineering concerns, and a lifelong Conservative, be placed, but between the Red Dean of Canterbury and H. M. Minister of Health? It is surely right that the lately appointed head of a hydraulics research laboratory, a recent graduate to the dais, should find himself bewildered by the unscientific half-truths of a noted back-bencher; and that, seeking solace upon his other side he should become involved in a discussion of Aztec civilisation with a professor from Cambridge! The civil engineering consultant should converse with the art critic; the metallurgist with a concert singer; the locomotive builder must be encouraged to discuss whales with an Antartic explorer; and the aeronautical expert from Farnborough must show intelligent interest in the cultural characteristics of Stone Age man, the age of the Universe, or the technique of the ballet. Nor is there any escape from the dilemma. It has but two horns. If there is to be talk at all it must be with the man on the right or the man on the left. There is no kindred spirit opposite whose conversation can be monopolised, nor anyone diagonally to right or left to introduce a more congenial subject. Nor can sullen silence be maintained. For in one so prominently placed upon the dais it is galling to seem to others wholly neglected as a dullard by one's neighbours! Somehow the eminent man must prove himself able, with no opportunity for prior study, to converse upon any subject, however abstruse, however unheard of. What could be more catholic, more liberalising?

Nor is that all. The discipline goes further. Above all, those at the top table must set an example. No fierce arguments may develop; the table must not be thumped. Nor, if more friendly relations have been established, should a neighbour be dug in the ribs with a thumb. The tired and overworked engineer, longing only for bed, must listen politely to heresies and bear patiently with he who "hath a heart as sound as a bell and his tongue is the clapper." For it is an essential part of his renewed schooling that he should learn modestly to realise that the antiquarian, the actor, the artist, the lawyer, the doctor, the accountant, the economist, the statistician, the explorer, "the butcher, the baker, the candlestick-maker" will need, just as politely as he, to keep straight faces when confronted by the more astonishing of his own opinions. A couple of centuries ago a man at dinner pressed beyond all bearing by the tedium or the incomprehensibility of his neighbour's conversation, was permitted, on pain of taking distressing consequences, to fling a glass of wine in his face. But not to-day! However much an engineer may be shocked by his neighbour's opinions or angered by his ignorance he must not show it. He must, indeed, at the top table, submit to the discipline and prove a very model of decorum. If he is near the Chair he must even assume an interest he is far from feeling in the dullest of dull speeches; and though placed further away along the dias he is still expected at least to shun that facility, so freely utilised elsewhere in the hall, of relieving the tedium of somebody's speech by continuing to converse. No doubt there is wisdom in submitting the eminent to this discipline of top-table dining. It cannot, of course, be ensured thereby that all the eminent come to resemble Mycroft Holmes, of whom his brother Sherlock once said: "All other men are specialists but his specialism is omniscience." But it can be supposed that those whose specialised knowledge has given them power over other men will thus be made to appreciate that the subject of their studies is not necessarily more important than any other in the world. For ourselves we have but one question left. No doubt it will be deemed a question of but little consequence. But here it is. Is the lesson, we wonder, really necessary? For in our experience of them the eminent seem to have learnt it long before they are asked out to dine!

Hydro-Electric Works on the Lower Dnieper

THE DNIEPER power development plan, recently announced by the U.S.S.R., envisages a 250MW hydro-electric station near Kakhovka. Its main object is to supply increased power to industry and agriculture in South Ukraine and North Crimea.

It is also proposed to use the impounded water from the river to irrigate the land in the basin of the river. The scheme calls for a hydro-electric station at Kakhovka with an annual capacity of 1200 million kWh. A dam to be erected on the Lower Dnieper will improve the river navigation and create a storage reservoir of over 11 million acre-feet, provided with a system of locks and pumping stations. In addition there will be a canal 345 miles long between Zaporojie on the Dnieper and the city of Kertch (Eastern Crimea). The scheme also includes various auxiliary works, in particular a dam on the Molotchnaya River, north of Melitopol, with a storage capacity of nearly 5 million acre-feet and a hydro-electric station of 10MW. Another canal, 38 miles long, will link Askania Nova with Kakhovka. There will also be three irrigation canals with an overall length of 190 miles, provided with pumping stations. The works were started at the beginning of 1951 and are due for completion in 1956 as regards the Kakhovka power station, and in 1957 as regards the irrigation canals and reservoirs.

SHORT NOTICES

Structural Theory and Design, Volume I. By J. McHardy Young, B.Sc., M.I.Struct.E. London: Crosby Lockwood and Son, Ltd., 39, Thurloe Street, S.W.7. Price 25s.—"Structural Theory and Design" is intended mainly for the student, but it has been written with the aim of combining, to some extent, the practical aspects of structural engineering with the theoretical work of design. The author's view is that structural design can be learnt only by experience, but the application of first principles to practice can be usefully indicated in a work which deals with methods of vigorous analysis. The book has been divided into two volumes, the second volume being more advanced, and should cover the syllabus of a degree or associate membership examination in the theory of structures. Volume I opens with a chapter about structural materials, and goes on to demonstrate the basic knowledge of elastic theorems and analyses of single beams necessary to understand the subject (a basic knowledge of mathematics and mechanics is assumed). The subject is then developed to deal with deflections and continuous beams in some detail, and there is a chapter devoted to design, in which examples of a design in steelwork and reinforced concrete are given. There are then chapters on single-framed structures and columns and struts. The use of advanced mathematics has been avoided wherever possible, emphasis being placed on methods of successive approximation. There are various appendices giving structural data for steelwork and reinforced concrete.

Explanatory Handbook on the B.S. Code of Practice for Reinforced Concrete. By W. L. Scott, M.I.C.E., W. H. Glanville, D.Sc., M.I.C.E., and F. G. Thomas, Ph.D., M.I.C.E., London: Concrete Publications, Ltd., 14, Dartmouth Street, S.W.1. Price 9s.—In its form and substance, this handbook follows the lines of the handbook on the D.S.I.R. Code of Practice issued in 1934. It is, however, based on the 1948 B.S. Code of Practice for the Structural Use of Normal Reinforced Concrete in Buildings (C.P. 114), the code being reproduced in its entirety, with the authors' comments and explanations following the various clauses. Many tables are also given to aid design according to the code. The handbook should prove a valuable and authoritative work of reference to the reinforced concrete designer.

BOOKS RECEIVED

Getriebelehre. By Otto Kraemer. Karlsruhe: G. Braun, Karl-Friedrich-Strasse 14. Price 16 Dmk.

Electrical Year Book, 1951. Manchester: Emmott and Co., Ltd., 31, King Street West, Price 3s.

Dynamik des Bogenträgers und Kreisringes. By von Karl Federhofer. Vienna: Springer-Verlag, Mölkerbastei 5.

Principles of Surveying. By James Clendinning. London: Blackie and Son, Ltd., 66, Chandos Place, W.C.2. Price 20s.

Benelux Importers' and Exporters' Guide. Second edition. Antwerp: Economic Documentation Office, Hilversum.

Mechanical World Year Book, 1951. Manchester: Emmott and Co., Ltd., 31, King Street West, Price 3s. 6d.

Obituary

A. S. E. ACKERMANN

THE death of Mr. Alfred S. E. Ackermann, which occurred on April 7th at 9, Rotherwick Road, Golders Green, London, N.W.11, will be keenly regretted by his numerous friends in the engineering profession. Mr. Ackermann, who was in his eighty-fourth year, had practised in Westminster as a consultant for over forty years, and, for most of that period, he acted as secretary to the Society of Engineers.

A. S. E. Ackermann was born in London in 1867. He was educated at the South African College—now the University of Cape Town—and at the City and Guilds (Engineering) College, where at one time he was laboratory assistant to the late Professor W. C. Unwin. After a few years in engineering works, Ackermann started his consulting practice. His work included the testing and reporting upon all kinds of machinery and advising on fuel economy, boiler-house installations and problems concerned with noise and vibration. He was also greatly interested in the utilisation of solar energy, and in the course of his career made three visits to the U.S.A., mainly in connection with the erection and testing of plant devised for using solar energy.

In the first World War, Mr. Ackermann was attached to the Controlled Establishments Division of the Ministry of Munitions, his duties including the study of the war and pre-war work of the factories of controlled firms, and advising the Ministry on additional installations of plant and machinery. Towards the end of the war he was called upon to act as Consulting Engineer to the Controller of National Aircraft Factories. When he resumed his own practice in 1919, Mr. Ackermann devoted a good deal of attention to "ancient lights," and among his inventions was a skymeter for use in cases arising from ancient lights disputes.

Mr. Ackermann was appointed honorary secretary of the Civil and Mechanical Engineers' Society in 1898, and a few years later he took up the secretaryship of the Society of Engineers. In 1910 there was an amalgamation of the two societies and Ackermann continued as secretary of the newly constituted Society of Engineers until his retirement in 1938. The successful work accomplished by the Society is in no small measure attributable to the keenness and energy with which Ackermann handled its affairs. In recognition of his work and of his contributions to its "Proceedings," Mr. Ackermann received the Society Premium on four different occasions, and he was twice awarded a President's Gold Medal. Before his retirement he was elected to Honorary Fellowship of the Society of Engineers. Ackermann was also a Fellow of the City and Guilds Institute and an associate member of the Institution of Civil Engineers, and, from 1921 to 1923 was chairman of Convocation of the University of London. He will be remembered, too, as the author of two interesting little books entitled "Scientific Paradoxes and Problems" and "Popular Fallacies."

J. W. TIERNEY

WE record with regret the death of Mr. John Wilbur Tierney, which occurred at his home at Eastbourne on April 5th. He will be remembered as a pioneer of the pneumatic tool industry in this country, having founded the Globe Pneumatic Engineering Company, Ltd., in 1904.

Mr. Tierney was born in America on May 24, 1869, and received his general education at a private school in New York. He then spent four years studying engineering at Spring Garden Institute, Philadelphia, and at Cornell University. At the age of nineteen Tierney joined the staff of the Barr Pump Engine Company, Philadelphia, as a draughtsman. He remained with that company for ten years, becoming chief draughtsman and designer, and taking charge of the erection of large waterworks pumping plant. His next appointment was with the Philadelphia Pneumatic Tool Company, of which he was president from 1900 to 1903.

In the following year Mr. Tierney came to England and formed the Globe Pneumatic Engineering Company, Ltd. He was responsible, during the years which followed, for designing and patenting a large number of pneumatic tools for which use was found in an increasing number of industries. In Mr. Tierney's early days in this country the production of his pneumatic riveting and chipping hammers was entrusted to the gun department of the Elswick works of Armstrong Whitworth and Co., Ltd. Shipbuilding was one of the first industries in this country to take up Tierney's equipment, and, soon after its formation, his company was supplying air compressors, pneumatic riveting and chipping hammers, drilling machines and kindred tools to the shipyards. Mr. Tierney's subsequent journeys abroad resulted in the equipment with pneumatic tools of naval yards in Russia, Japan and Italy, as well as railway workshops in many parts of the world.

Tierney was a skilled engineer and an enthusiastic designer. He spent the greater part of his long working life in assisting the development of the company which he started in this country forty-seven years ago, and although in recent months he had reduced some of his activity, he continued as chairman and managing director up till the time of his death. Mr. Tierney was elected to membership of the Institution of Civil Engineers in 1943 at the age of seventy-three.

W. G. A. PERRING, C.B.

IT is with regret that we record the sudden death of Mr. William George Arthur Perring, following a heart attack at his home in Camberley, Surrey, on April 9th. Mr. Perring, who was fifty-two years of age, had been the Director of the Royal Aircraft Establishment, Farnborough, since 1945, was a Fellow and Vice-President of the Royal Aeronautical Society, and a member of the Aeronautical Research Council.

Mr. Perring was born on December 16, 1898, and educated at H.M. Dockyard School, Chatham, and the Royal Naval College, Greenwich, where he took a first-class professional certificate in naval architecture. From 1923 to 1925 he was a research scholar at the William Froude Tank, National Physical Laboratory, Teddington. In 1925, Perring joined the Royal Aircraft Establishment as a junior technical assistant, and by 1927 the Aeronautical Research Council had published his first report, which dealt with the characteristics of aerofoils and with wind tunnel tests on high-speed airscrews. Much of his subsequent work was devoted to research in this field. His other researches included investigations of flutter, of engine nacelle drag, and cowling design, and one report indicated his interest in boundary layer control. A considerable portion of his work up to 1942, by which time he had become the author of some thirty reports published by the Aeronautical Research Council, was devoted to the water performance of flying-boats. There are many records of his work on the hydrodynamics of planing surfaces and the influence of scale and tank effects on this research. Perring originated a particular application of dynamical similarity methods towards the determination of the porpoising characteristics of seaplanes. His last report, in 1942, was concerned with the influence of propeller-leading edge distance upon propeller vibration.

In 1940 Mr. Perring was made Superintendent of Scientific Research at Farnborough, and in July, 1941, was appointed Deputy Director of Research and Development, in which post he continued until his appointment as Director of the Establishment in 1946.

Amongst his many outstanding achievements was the design of the 10ft by 7ft high-speed tunnel at Farnborough. This design enabled the tunnel to be put into action during the war without any development period, and it has since played a major part in the design of British high-speed aircraft. During the war Mr. Perring devoted his energies to the many problems affecting aircraft, directing the research resources of the Establishment to the spheres in which they were most needed. At the same time, he recognised the importance of new developments in high-speed aircraft made possible by the introduction of the jet engine, and began the re-equipment of the Establishment to deal with these matters. He played a prominent part in overcoming the difficulties associated with the creation of the new National Aeronautical Establishment at Bedford, of which he was Director Designate, and he had himself supervised the designs of the large wind tunnels and other equipment.

In 1949 his great service to the nation was recognised by the award of the C.B. by the King.

Literature

Die Tragfähigkeit der Zahnräder (*The Load-Carrying Capacity of Gears*). By A. K. THOMAS. Carl Hanser Verlag, Münich: Leonhart Eck-Strasse. Price 12DM.

As the author explains in his preface, the principal object of his book is to set out the methods of calculating the load-carrying capacity of gears; but the several limitations of strength, wear and temperature make it necessary to include also certain aspects of gear geometry (tooth proportions, methods of correction and detail dimensions), conditions of mounting, efficiency, lubrication and cooling. These matters, together with the calculation of bearing loads, data on gear wheel design, shaft stresses and deflections, and a number of worked examples, are set out under the headings of spur, helical, bevel, worm and spiral gears.

The book is designed to serve as a handbook for use in design offices rather than as a textbook for conveying an understanding of first principles. It could not otherwise have been condensed to its 172 pages. Thus, whilst some sections open with, or contain, explanatory matter, the majority consist of the notation and statements of formulæ to be used for the various calculations, the derivation being usually omitted. The sources are chiefly German publications and D.I.N. standards, and references are given.

Whilst geometrical considerations in gear design, being susceptible of demonstration, are not of a controversial character, the ultimate questions which relate to load carrying capacity offer much scope for difference of opinion, whether they concern the bases upon which criteria of load-carrying capacity should rest, or the empirical constants such as working stresses and other

factors which the designer derives from experience as best he may.

On some of these questions, such as tooth strength factors and criteria for surface loading, there are marked differences between German and British practice. Together with corresponding differences in design constants, they indicate the range of probable uncertainty on both sides. In the case, for example, of a pair of high-class case-hardened steel gears having twenty and forty teeth, 5 D.P., 1in face width, and running at 2400ft per minute, the continuous (25,000-hour life) ratings for permissible tooth load by Thomas and B.S.S. formulæ are respectively 850 lb and 1350 lb for wear and 2560 lb and 1215 lb for strength. For a life of 2500 hours the corresponding wear ratings are 1240 lb and 2700 lb.

The British designer who is merely in search of rules and formulæ will not find, in this book, data not already available in British publications on gears, and the fact that it is in German will restrict its circle of potential readers in this country. But to those who are interested in the bases of methods for the calculation of gear ratings, the book will enable many illuminating comparisons to be made between German and British practice—at the cost of some laborious translation of notation and conversion of units. Since the formulæ published in both countries have presumably been used without widespread catastrophe, useful indications may thus be gained of the directions in which British standard practice may be more cautious than perhaps it need be. This in turn may prompt fuller investigation of the many problems in gear behaviour which still remain unsolved. Until then, the slavish use of design formulæ will continue to lead to unnecessary safety or unsuspected danger.

Scottish Railways. By O. S. Nock. London: Thomas Nelson and Sons, Ltd., 3, Henrietta Street, W.C.2. Price 18s.

Why are the railways of Scotland more romantic than those of England? Why is it that as we draw nearer and nearer the Border we feel a charm working within us? The railways of Cumberland and Westmorland, of Derbyshire and Warwick, have beauties unexcelled, and who is there who, having sojourned abroad, returns through Kent in the spring or summer that is not moved by its loveliness? Yet the railways of England lack the romance that attaches to those of Scotland. Why is it? It cannot be due to the names of stations and areas alone, poetic and musical as they sound to southern ears. The "Elephant and Castle" done into Gaelic would still be no more than the name of a public house. Nor can it be a reflection of the feuds that were in early days sustained by rival companies, for few of those who travel through the Lowlands into the Highlands know aught of those feuds, and battles, and intrigues that marked the inception of Scottish railways, or of the competition and pride of opposing lines. We fear there is no answer; why they are more romantic, or more "fascinating," as Mr. Nock has it, must remain unexplained.

Mr. Nock, an author well known to readers of The Engineer, opens his volume with a chapter of history. Now the history of railways in all countries, and especially Great Britain, is nearly always involved. Railways, sometimes no more than a few miles long, spring up by the dozen and only by difficult courses were they slowly amalgamated into greater companies, or absorbed into greater units. To present a concise history of these events calls for the skill and patience of one who undertakes the unravelling of a very tangled skein. Our author performs the task for the railways of Scotland with transparent success and in an atmosphere of that romance to which we have alluded. To give examples will perhaps destroy "the undefinable fascination." In the present blasé century few can hope to catch again the enthusiasms that were aroused in early Victorian days by the speed of railway trains and the vistas of trees and mountains, rivers, seas and tunnels that were opened by the railways to the public eye. Yet we must touch upon one or two matters to show the stuff of which Mr. Nock's chapter is made.

We have said that it is difficult to define the qualities and attributes of romance. But there is one that has been selected by poets from time immemorial. It is man's struggle with man in battle and feud. Particularly is that true of the Northern parts of this Kingdom as witness the wild minstrelsy of the Border. Now the railways of Scotland were born in animosity and reached their maturity in bitter competition—competition so personal as to be hardly distinguishable from vendetta. Take, for example, the deadly rivalry between the G. and S.W.R. and the Caledonian. It recurs again and again in the history of "Scottish Railways." Or, again, take the competition between the Highland Railway—set in "sublime mountain country" and "steeped in romance"—and the North British over Inverness. "The Highland Railway looked upon Inverness as their very own, and the merest suggestion that any other company might share the traffic was enough to set the heather on fire." Or, yet again, the "dreadful feuds between the Great North of Scotland Railways and the Highland."

So it goes on; but we must leave Mr. Nock's historical review of the "big five" railways of Scotland and the famous Portpatrick, and glance at other pages.

As a matter of fact, it is almost enough to quote the headings of the chapters to give the reader a fair idea of the substance of this volume. First comes an outline of "Scottish Railways in Industry, Commerce and Sport," followed by one on "Passenger Train Services," which recalls the names of many famous trains such as the "Midday Scot," the "Royal Scot," the "Night Scotsman," "The Coronation Scot" and "The Flying Scotsman." Mr. Nock speaks from personal acquaintance with many of the trains he mentions, and picks the "Coronation" as "one of the most beautiful trains that have ever run in Great Britain." The next chapter deals with the "Great Scenic Routes of the West and North Highlands," and again our author gives his own impression and records his own experiences. Then we have an excellent chapter on "Railway Engineering and Architecture," in which Mr. Nock's engineering knowledge aids his descriptions. It is followed by one on "Traffic Control and Signalling" subjects in which he is expert. We come, then, to two chapters that cover "Locomotive Building and Running in Scotland." Here the author's many footplate experiences are happily recorded in a manner familiar to readers of The Engineer. We are sorely tempted to linger over them, but must draw to a close merely adding that the book contains many portraits of engines in their original colours besides half-tones and outlines.

One word to conclude. We cannot imagine a book that is more likely to appeal to the numerous visitors to this country in this especial year who desire to see the romantic country of the North and to travel on British Railways at their best.

Oilfield Exploration and Development. Vols. I and II. Second edition with appendices. By A. Beeby Thompson, M.I. Mech.E., M.Inst.M.M., F.G.S. Surrey: The Technical Press, Ltd., Gloucester Road, Kingston Hill. Price 84s. per set.

The first edition of this book, published in 1925, was, in its day, a classic in the petroleum industry and, though much of it is now out of date, many of the basic principles laid down therein still hold good. In this second edition the author has added new material in the form of appendices, which summarise the progress made in oilfield technology, practice and development and in refining since the original publication. Introducing these additions, he states that "so much has happened in almost every branch of the petroleum industry that it is beyond the power of any single individual to do justice to so great a subject." He has, nevertheless, in seventy pages of highly condensed material, covered an immense amount of ground and has produced a digest of the more important developments which, if it does not provide much detailed information, does give a broad review of the great progress made.

The author's gift for well-turned technical phraseology has enabled him to describe in a few lines developments of great scope and to convey his views to the reader with a great economy of words. After an introductory review in which geophysical and aerial survey methods are discussed, the Appendices to Volume I include a resumé of the major oil discoveries since 1925, with any outstanding geological or geographical features. Production figures are included and some estimates of reserves. Political aspects are occasionally touched upon, where relevant to the development of the country. A schedule of world production figures up to the end of 1948 is given.

The Appendices to Volume II commence with a summary of modern refinery operations concisely described and concluding with a note on special petroleum derivatives. Drilling technique is briefly dealt with and though the author has included a vast amount of information on improvements and new practice, which have been evolved since the original publication, he has not, unfortunately, found it possible to give many of these the space they deserve. A certain amount of detailed information is supplied on the complex nature of the drilling problems in the Khaur field in the Punjab, but improvements to rig and tool design, verticality of wells, directional drilling, off-shore drilling, pressure drilling, mud chemistry and many other sections of absorbing interest, have been somewhat severely condensed. The development of electric logging is discussed more fully and a note of some interest on future developments is added. A section is devoted to oil recovery by natural flow, pumping and gaslift, followed by an interesting discussion on secondary recovery methods. Finally, the extraction of gasoline and light hydrocarbon fractions from natural gas is described with information on practice and plant in use in U.S.A.

Though these additions constitute a broad and comprehensive review of progress made over a period of some twenty-three years, it must be a matter of considerable regret that the author, whose knowledge of oilfield technology in all its branches is second to none, has found it impossible to revise his book in greater detail.

A Formula for Ship and Model Skin Friction Resistance

By G. G. McDONALD, Ph.D., M.I.N.A.*

NAVAL architects have, in the past, estimated the skin friction coefficient for the full-size ship by adding a "roughness allowance" to the friction coefficient obtained from tank tests on models. An alternative procedure, in the form of an empirical skin friction formula for the transition region between the smooth-turbulent and rough-turbulent types of flow is offered in the present note. The expression depends on a mathematical relationship which was used by Dr. C. F. Colebrook and Professor C. M. White†, and recently by Professor L. F. Moody‡ in connection with the flow of fluids in rough pipes.

Consider a flat surface of length L (feet) and area S (square feet) over which a fluid of density ρ (pounds per cubic foot) and kinematic viscosity ν (square feet per second) is moving with speed V (feet per second). The frictional drag acting on the surface is F (pounds) and the skin friction coefficient is given by $C_f=2gF/\rho SV^2$. $g=32\cdot2$ (feet per second per second).

Surface Roughness

The absolute roughness of the surface is represented by k (feet), the relative roughness by $r=k/L$ and the relative smoothness by $\sigma=1/r=L/k$, where k is the height of the roughness excrescences on the surface. The Reynolds' number for the surface is $R=VL/\nu$, and the absolute roughness Reynolds' number or grain Reynolds' number is $Rr=Vk/\nu$.

The Reynolds' numbers encountered in ship-model and full-size ship resistance investigations range from 5×10^5 to 5×10^9, the latter representing R for a liner 1000ft long moving at 50ft per second with $\nu=10^{-5}$.

The absolute roughness k may be of the order of 10^{-3} to 10^{-4} (feet) for clean paint on steel giving a relative smoothness σ from 10^6 to 10^7 for a ship 1000ft long. For a ship-model 10ft long, with k about 10^{-4}, σ would be about 10^5. A range of relative smoothness of 10^5 to 10^7 would seem to cover ship-model and full-size ship skin roughnesses satisfactorily.

Smooth-Turbulent Flow

For smooth-turbulent flow, $k=0$, and the well-known expression proposed many years ago by Professor E. V. Telfer can be used for skin friction between $R=5\times10^5$ and $R=5\times10^9$.

$$C_{fs}=0\cdot0012+(0\cdot34/R^{\frac{1}{3}}) \quad . \quad . \quad . \quad . \quad (1)$$

or

$$C_{fs}=0\cdot0012+(3\cdot94/10^2R)^{\frac{1}{3}} \quad . \quad . \quad . \quad (2)$$

This coefficient is independent of the relative smoothness.

Rough-Turbulent Flow

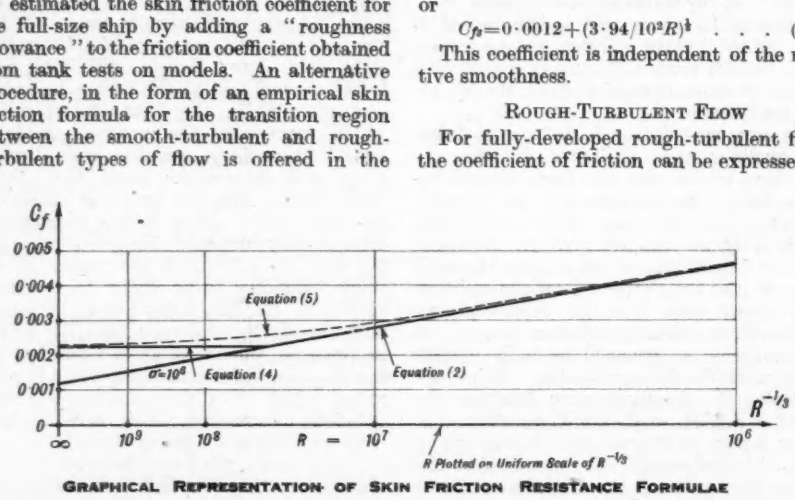
For fully-developed rough-turbulent flow, the coefficient of friction can be expressed in the form proposed by H. Schlichting,

$$C_{fr}=1/(1\cdot89+1\cdot62\log\sigma)^{2\cdot5} \quad . \quad . \quad . \quad (3)$$

This coefficient is independent of Reynolds' number.

In the range $\sigma=10^5$ to 10^7 equation (3) can be replaced within ±3 per cent by

$$C_{fr}=0\cdot0012+(8/10^4\sigma)^{\frac{1}{3}} \quad . \quad . \quad . \quad . \quad (4)$$



GRAPHICAL REPRESENTATION OF SKIN FRICTION RESISTANCE FORMULAE

Smooth to Rough-Turbulent Transitional Flow

The combination of equations (2) and (4), of similar structure, provides the required empirical transition formula.

$$C_f=0\cdot0012+\{(3\cdot94/10^2R)+(8/10^4\sigma)\}^{\frac{1}{3}} \quad (5)$$

When R approaches the value 5×10^9, equation (5) approaches the value given by equation (4), and when R tends towards the value 5×10^5, equation (5) tends to the value given by equation (2).

When $k=0$, equation (5) reduces to Telfer's form, equation (2).

Equation (5) is thus asymptotic to equations (2) and (4) at the extremes of the Reynolds' range for values of σ between 10^5 and 10^7.

When $Rr=Vk/\nu$ is greater than about 2 to 3×10^3, fully-developed turbulent flow obtains in the range of relative smoothness $\sigma=10^5$ to 10^7, when R is in the neighbourhood of 5×10^9. Most ship-models and full-size ships, however, will have Reynolds' numbers which fall in the transition region where Rr is less than, say, 2×10^3, hence the value of an empirical transition formula such as (5) for approximate calculations of the skin friction resistance of ship-models and their full-size prototypes.

Graphical Representation of the Formula

The accompanying diagram shows the transition formula (5) plotted as a dotted curve for the case where the relative smoothness $\sigma=10^6$. Also drawn as full lines are Telfer's "extrapolator" equation (2) and equation (4) for fully-developed turbulent flow with $\sigma=10^6$.

A General Equation for Transition

Equation (5) is limited in scope, but it is as simple as it can be made. Adopting expressions for boundary layer behaviour in the smooth-turbulent and tough-turbulent régimes established by L. Prandtl, Th. Von Karman, and modified by K. E. Schoenherr and H. Schlichting it should be possible to build up an empirical transition formula of the form

$$C_f=[a\log\{(b/RC_f)^c+(d/\sigma C_f^{\frac{1}{2}})^c\}]^{-2} \quad . \quad (6)$$

in which a, b, c, d, and e are non-dimensional constants. Equation (6), however, is an implicit function of C_f and extremely tedious to solve for C_f without the help of tables or curves.

* Professor of Mechanical Engineering at the University of Sydney, Australia.

† "Proc.," Inst.C.E., Feb., 1939, pages 133–156.

‡ *Mechanical Engineering*, Vol. 69 (1947), pages 1005–6.

Course on Electronics at the College of Aeronautics

THE subject of electronics has attained particular significance in the field of aeronautics, where, amongst its many applications, are those to flight and navigational aids, air traffic control and guided missiles. Because of its importance to current aeronautical development and to meet the growing demand for men trained both in aeronautical and in electrical engineering, the College of Aeronautics is extending the present electrical section and is introducing a combined two-year course in these subjects, starting in October, 1951.

The aim of the course is to give students a fundamental grounding in aeronautical engineering in general, together with a more specialist training in those branches of electrical engineering which find application in the aeronautical field.

The electrical section in the first year is divided under the five main headings of applied electronics, communications, aircraft electrical systems, servo-mechanisms and aerials. Applied electronics covers fundamental principles and deals with the application of electrical and electronic techniques in the measurement of physical and mechanical quantities. The general principles of communication to and from aircraft are considered, as are the problems of supply and utilisation of electrical power in aircraft.

The fundamental theory of servo-mechanisms is examined in some detail, and all forms of automatic control systems, such as automatic pilots and power-operated flying controls are discussed with examples of current practice. Because of the need to suppress within the aircraft skin the aerials of high-speed aircraft the fundamental theory of aerials is treated in detail.

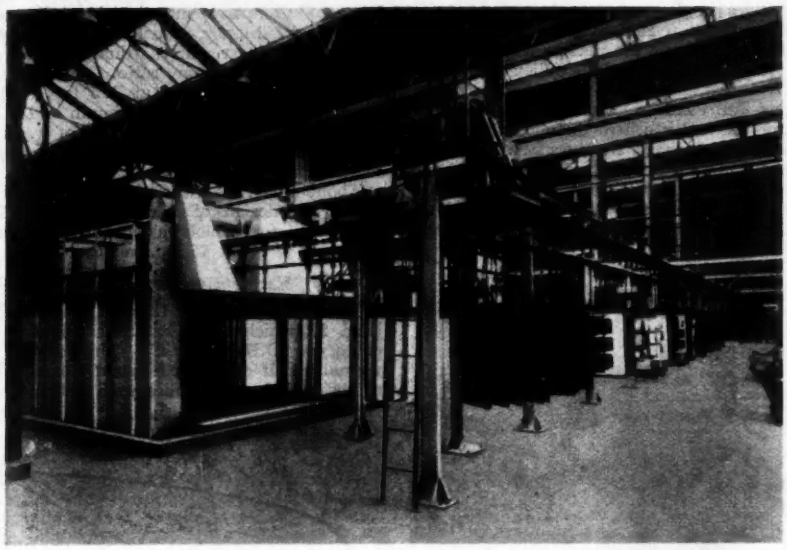
During the second year the foregoing subjects are continued, but the student is allowed to specialise and to undertake research work to form the subject of a thesis.

The course leads to the Diploma of the College. Students on entry should preferably have a degree or Higher National Certificate in mechanical or electrical engineering or a degree in physics.

INDUSTRIAL ART BURSARIES.—The Royal Society of Arts has now published the report on the Industrial Art Bursaries Competition, which it held in 1950. The report states that awards to the value of £1705 have been made to enable winning candidates to travel abroad so as to broaden their knowledge and experience. The encouragement of industrial design has been one of the primary objects of the Royal Society of Arts since its foundation in 1754, and awards of one sort or another have frequently been offered to promote this end. In recent years the annual competitions have been among the Society's major activities. The greater part of the cost of the awards in the competitions has been subscribed by industry, many branches of which have regularly made generous contributions and shown continual interest in the Society's work. Competitions in the present form, the purpose of which is to encourage art school students to take up industrial design as a career, started in 1938, and a sum of £5970 has been awarded in the nine competitions since held. (They were suspended between 1942–1945.) These competitions differ from earlier ones in awarding a few large bursaries, rather than numerous small prizes, to allow students of promise to derive the fullest possible benefit from their visits abroad. The report can be obtained from the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

An Electric Cooker Factory

A RECENT visit to the Swinton works of the General Electric Company, Ltd., gave us an opportunity of seeing what the company has been doing to satisfy the very heavy post-war demand for electric cookers. After the war, when the Magnet cooker works in Birmingham was feeling the effects of the local labour shortage, efforts were made by the company to find a suitable factory in an area where reserves of labour were to be found. Eventually, a factory, which was formerly engaged in munitions work, was acquired at Swinton, near Mexborough, Yorks. The factory had been making armour-piercing bombs and aircraft components, but it had fallen into disrepair and, in any event, much of the plant was unsuitable for conversion to cooker manufacture. While there was plenty of local labour, little of it was skilled in electrical work. However, in spite of the difficulty of re-equipping and restaffing the factory for its new production, the first completed cooker was completed and despatched only three months after the acquisition of the factory.



COOKER SIDE PANELS ENTERING VITREOUS ENAMELLING FURNACE

The works stand on a site of about 24 acres and provide 400,000 square feet of working space under one roof. The factory includes a new building designed to house the pickling, plating, polishing and shot blasting departments, and a rail and van loading dock built at the far end of the main building. The labour force is about 1200 strong, drawn almost entirely from local sources and trained by a few instructors from the Birmingham works.

Although the plant is adequate for an output of about 2000 cookers per week, present production depends on the supply of raw materials.

Production in the factory is based on a number of self-contained departments, or groups of departments, which fabricate the various cooker parts and pass them on to a finished parts store, where they remain until required for assembly on the cooker production lines. The major parts of the G.E.C. electric cooker are fabricated from grey cast iron and sheet steel of enamelling quality. The first operation, therefore, begins when the sheet steel is received in the store at one end of the fabrication department and passes, as required, to machines for cutting, forming and welding. The parts are then stored to await processing. The fabrication department is equipped with power presses up to 200 tons rating, various types of welding machines (including a 50kVA, 400V seam welder for making steam-tight oven bodies), and machines specially designed for surfacing hot plates and grill boiler castings. Cast components are received in the castings stores and later are machined and subsequently annealed. The cast components and fabricated sheet metal parts are then cleaned in readiness for vitreous enamelling, the cast iron parts being shot blasted and the sheet steel degreased and pickled.

Vitreous Enamelling

The next stage in the manufacture of the major cast iron and steel parts of the cooker is the application of vitreous enamel, which takes place in a large, self-contained department within which the enamel is prepared, applied and fired.

Preparation of the enamel in slip form, so that it can be applied to metal, takes place in a mill room equipped with ball mills of 600 lb to 1 ton capacity. The mills consist of large revolving drums lined with white porcelain blocks and with a grinding medium of flint pebbles. The mills are erected around a platform so that they can be conveniently charged from above with the ingredients that form the enamel slip.

For application to the metal the prepared enamel slip is supplied to spray booths and dipping tanks adjacent to the mill room. The dipping tanks are used in the first operation, in which the fabricated steel panels are dipped in a grey-blue ground-coat enamel. After drying, this coat is then fused to the panels which are subsequently returned to the spray booths so that the final coat of enamel can be sprayed on the face of the panels. After each dipping, or spraying, operation the panels are passed through steam-heated drying chambers, to evaporate water which has been used solely as a carrying agent for the fine particles of powdered enamel. The ware is then passed on to brushing benches where, if required for decorative purposes, part of the top coat of enamel is removed by brushing before fusing.

Fusing of enamel to metal takes place in a furnace at an approximate temperature of 840 deg. Cent. For this process there are five furnaces, one of which is an electrically operated 750kW furnace for continuous processing, 75ft in length, and fed by a 380ft endless conveyor system as illustrated herewith. In this travelling furnace gradual heating is arranged before the parts reach the hot zone, and, similarly, gradual cooling before reaching the air again. To ensure accurate temperature control a signalling system is employed to give immediate warning of a drop in temperature and to indicate which of the four heat zones is affected. The belt on the continuous mechanical overhead conveyor is made of nickel alloy to withstand continuous reheating at high temperature. Spaced at every yard of its 130-yard length are nickel alloy racks from which the ware is suspended as it travels through the furnace at the rate of 2 yards a minute, spending approximately seven minutes in the hot zone itself. In passing we may mention that the complete furnace was erected on site by G.E.C. Swinton engineering staff. After the components have passed through the furnace they are unloaded, inspected and then passed through a bank of retapping machines in order to clear all threads of enamel before being sent to the finished parts store.

Small auxiliary parts of the cooker which do not have much wear and tear are stove enamelled in a separate department. There they are first dipped in enamel in slip form, loaded on to a conveyor and then passed through a continuous process infra-red drying tunnel. Should defects occur in the vitreous enamelling of the metal, the defective parts are returned to a de-enamelling department, where the enamel is removed in a modern molten caustic soda plant, the bath of which is constructed of 1in thick steel plate. Although the recovery of parts in this way would not perhaps be economical in normal times, in present conditions the process is regarded as being necessary to conserve steel.

Metal parts which cannot be vitreous enamelled are electro-plated as a form of protection or for decorative effect. The articles to be nickel-plated are first given a thin copper deposit. Chromium-plated articles are given a thin copper deposit and then a nickel undercoat, prior to going into the chromium vat. After drying, the plated parts are taken to the polishing department for finishing.

Hot Plate and Oven Elements

Hot plates and oven elements require a refractory insulating cement. The raw material is crushed and ground, passed through a magnetic separator to remove any metallic particles and mixed with a bond. Manufacture in the embedded hot plate department begins with the drilling and surfacing of hot plate castings. Then refractory cement in a semi-dry state is filled into grooves on the underside of the castings. Meanwhile, the resistor coils are wound for each particular voltage and to a predetermined length. End leads of an appropriate length are gathered in strands of varying numbers and fixed to the resistors by spot welding. The finished coils are laid in grooves, which have been made in the previously air-dried refractory. They are then almost covered with additional refractory material, inspected and covered with a final filling of refractory. The plates are then baked, after which each plate is placed on circuit for three minutes and flash tested. The plate is ultimately given a final consumption and flash test.

In the manufacture of grill boilers, the resistor coils are wound, stretched and coiled in two fireclay refractories. They are laid in the previously machined grill boiler casting and the beaded end leads are connected to three live plug pins. The elements for the grills are next checked for current consumption and inspected for correct assembly.

Sheathed wire elements, for ovens and radiant hot plates are manufactured in a separate department by a process designed to ensure concentricity of the resistor in relation to the outer sheath, and to effect even spacing of the resistor coils as well as uniform packing of the refractory within the tube.

All parts, after they have been tested and inspected at every stage of manufacture, are received in a finished parts store, which feeds the assembly shop with completed cooker components and separates it from the rest of the works. There is thus a continuous flow from the various departments through the finished parts store to the assembly shop.

In the assembly shop cookers are built up on turntable trollies which pass down a roller assembly line. There are eight lines in operation with the various assembly stations indicated by

numbered boards at either side. At these stations, semaphore signals operated by the assemblers indicate to the finished parts store whether or not fresh supplies of component parts are needed. Running parallel to the main assembly lines are sub-assembly benches on which sections of the cooker are put together and then passed to the main line for incorporation in the cooker. Inspectors and viewers check the work at each station as the growing product proceeds along the line. At the end of the track the cooker passes on to the nearest test board and the turntable trolley returns to the start of the assembly line.

On the test board the setting of the oven thermostat, the switch circuits, insulation and so forth are checked and a 1000V flash test applied. Each test board can accommodate twelve cookers at one time for a preheating test, but subsequently each is separately tested, checked and examined before passing into the central stores, where, in normal times, stocks are kept to meet orders from the company's home and overseas branches. Within the stores a special packing section deals with export orders. Special bulk packing cases, which permit six or ten cookers to travel in one case with much less risk of damage to enamel parts, are used for bulk supplies sent overseas.

Outside the main works are various departments that service the factory; they include a toolroom where press tools, jigs and gauges are made for works use. Adjoining the works is the administration block which houses a large conference room where there is a chronological display of electric cookers dating from 1906.

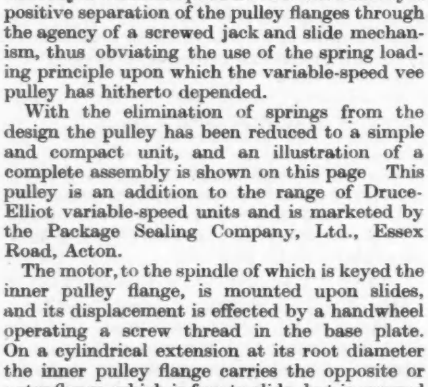
An Expanding Vee Pulley

WE were able to see recently a form of expanding pulley for vee-belt transmission, whereby a variable-speed drive is obtained by a positive separation of the pulley flanges through the agency of a screwed jack and slide mechanism, thus obviating the use of the spring loading principle upon which the variable-speed vee pulley has hitherto depended.

With the elimination of springs from the design the pulley has been reduced to a simple and compact unit, and an illustration of a complete assembly is shown on this page This pulley is an addition to the range of Druce-Elliot variable-speed units and is marketed by the Package Sealing Company, Ltd., Essex Road, Acton.

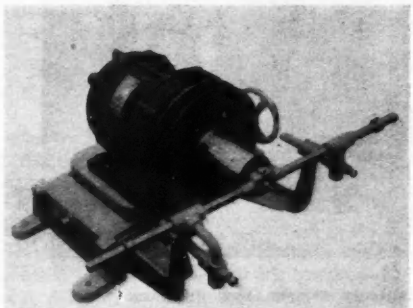
The motor, to the spindle of which is keyed the inner pulley flange, is mounted upon slides, and its displacement is effected by a handwheel operating a screw thread in the base plate. On a cylindrical extension at its root diameter the inner pulley flange carries the opposite or outer flange, which is free to slide, but is secured against relative rotation by driving splines. To encourage their slow rotation the driving splines are greased through the nipple at the main bearing. The outer flange runs on a double angular contact race and is supported by the cam bar, which, however, can pivot laterally about the connection. Adjustable brackets support the cam bar itself which is free to slide in a direction determined by the bracket bearings.

Both this cam bar and the slides upon which the motor is mounted are inclined at equal angles to the line of drive of the belt. On turning the handwheel the lateral component


Lubricator to Splines
C.L. Cam Bar (Secured to Outer Flange)
Movement of flanges in this direction opens pulley thus decreasing effective P.C.D.
Driving Splines
Outer Pulley Flange
Inner Pulley Flange Keyed Motor Shaft
Electric Motor
C.L. Motor Slides

CROSS SECTION OF VARIABLE SPEED DRIVE

of the motor displacement increases or decreases the flange gap setting, both flanges moving equal distances about the line of drive, whilst that component in a fore and aft direction adjusts the centre distances to compensate for changes in the arc of contact and retains the correct belt tension. From the geometry of this arrangement the makers state that for every ¼in displacement of the pulley centres the effective diameter of the variable pulley changes ¼in. This relationship assumes that for any particular centre distance the length of return belt between the normals of contact remains the same for any p.d.c. in the driving range. To compensate for the slight change which actually occurs over this range the vee section of the pulley is slightly modified and



MOTOR AND PULLEY ASSEMBLY

the generated profile of each flange assumes a slightly convexed form. This curvature is thought also to conform more nearly to the shape of the belt sides when distorted under tension.

Thus, through the control wheel, the flanges of the pulley can be opened or closed so as to increase or decrease the driving diameter, and hence increase or decrease speed as required, whilst at the same time the unit maintains the same belt tension and perfect alignment of the belt. All movements take place simultaneously so that whilst the unit is actually driving, an infinite variation in the speed ratio can be effected by turning the handwheel, which, if desired, can be operated through remote control. The drive remains positive, whether the ratios are being increased or decreased, and the conditions of an ordinary fixed vee-belt drive as to efficiency, &c., are maintained with no more strain and wear on the belt than would normally be caused by a fixed drive. Belt stretch can be taken up by adjustment of the cam bar brackets, it being unnecessary to touch either the motor or motor base. The unit is adjustable to any motor frame size, but is most suitable for power units ranging from fractional up to 10 h.p. There are six standard sizes of pulleys made from 3in to 12in providing maximum variations of ratios from 2 to 1 up to 5 to 1, using vee rope sizes from ¼in to 2in.

The Development of the De Havilland Series of Engines for Light Aircraft*

By J. L. P. BRODIE, M.I.Mech.E.†

IN 1915 a single-engined pusher bi-plane, with an all-up weight of just over 2000 lb and a speed of 80 m.p.h., made its initial flight. This machine, the D.H.1, inaugurated the long series of de Havilland aeroplanes, now numbering over 100 designs, all originating in the experimental work of Geoffrey de Havilland (now Sir Geoffrey) dating from 1909.

The principal interest of this paper in the D.H.1 aeroplane is in the power unit, an air-cooled Renault, eight-cylinder 90 deg. vee engine of 9 litres capacity, rated at 80 h.p. at 1800 r.p.m., the model for the series of light aeroplane engines to be described. This Renault engine had the high specific weight of about 5·5 lb per horsepower principally owing to its cast-iron cylinder and steel piston construction. It performed well during the 1914–18 war, first in the D.H.1 and later in the D.H.6.

A large stock of this engine remained at the end of the war and in 1924 the Aircraft Disposal Company introduced modifications to increase efficiency, namely, aluminium cylinder heads, larger valves, dual ignition and increased compression ratio. As a result the engine was re-rated at 125 h.p. at 1800 r.p.m., and developed a maximum of 144 h.p. at 2000 r.p.m., with a reduction of weight to 3·6 lb per horsepower based on normal rating—a marked improvement.

About this time Geoffrey de Havilland set about the design of a really practical light aeroplane, for which he concluded that a minimum of about 65 h.p. was required.

EARLY UPRIGHT ENGINES

The result was the "Cirrus I" of 4·5 litres (Fig. 2), which made its initial flight in the prototype D.H. "Moth." This engine was virtually half of the redesigned Renault, four of the cylinder assemblies with their connecting-rods, crankshaft and other components being installed in a new crankcase with a direct drive to the propeller. The engine, with a compression ratio of 4·65, was rated at 64 h.p. at 1800 r.p.m., developing a maximum of 68 h.p. at 2000 r.p.m. The weight, however, was 286 lb, representing an increase to 4·47 lb per horsepower on normal rating.

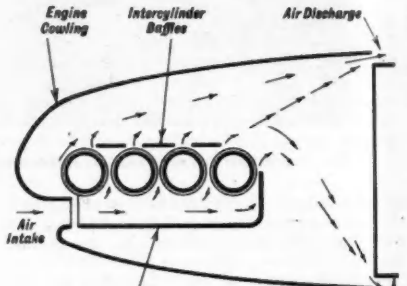


FIG. 1—*Diagram of Cooling System*, 1927–50

In 1927 Halford, working in closer co-operation with de Havilland, produced a new four-cylinder in-line upright engine, the "Gipsy." The capacity was 5·23 litres, bore 114mm, stroke 128mm, compression ratio 5·1, and speed 1900 r.p.m. normal and 2100 r.p.m. maximum. Cast-iron cylinders were used with aluminium alloy cylinder heads. The lay-out was conventional, the crankshaft running in five main bearings in an aluminium alloy crankcase.

A second Mark was produced in 1929, with the stroke increased to 140mm and the compression ratio to 5·2, developing 105 h.p. at 2000 r.p.m. normal or 120 h.p. at 2300

*Abstract. Institution of Mechanical Engineers, April 10th.

†Director, Engineering Division, De Havilland Engine Company, Ltd.

r.p.m. maximum, with a capacity of 5·71 litres. The dry weight was 298 lb, or 2·84 lb per horsepower on normal rating—about one-half the specific weight of the Renault engine of 1915. The increased speed and longer stroke represented a marked increase in mean piston speed, and for this reason the cylinder was redesigned as a carbon steel forging, machined all over, which enabled the cooling fins to be more closely spaced to increase the cooling area. The cooling system, which has remained substantially the same right up to the present time, is shown diagrammatically in Fig. 1. Its distinguishing feature is the use of inter-cylinder baffles to produce a pressurised system with turbulent flow through the finning.

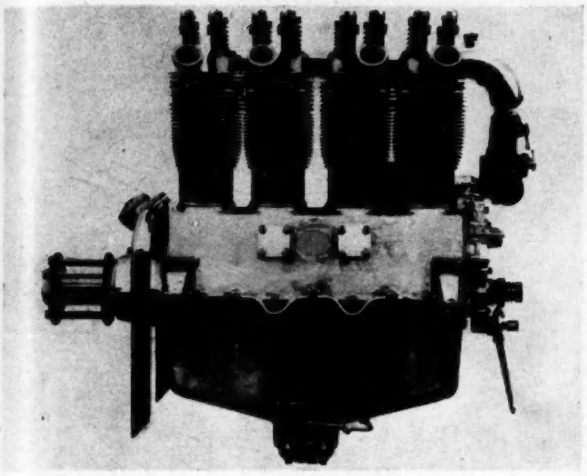


FIG. 2—*Cirrus I Engine*

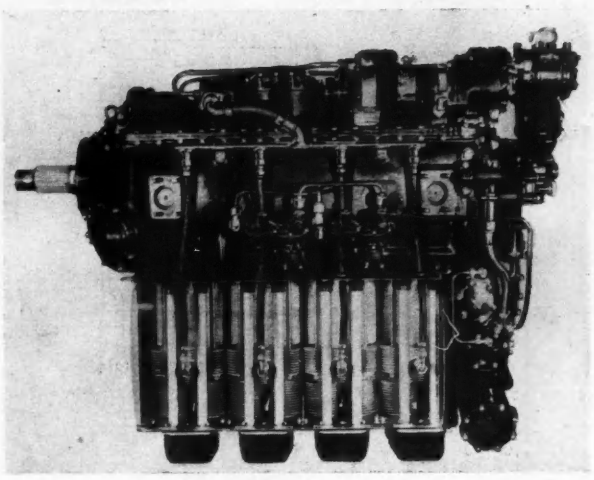


FIG. 3—*Major 30 Engine*

Inverted Engines

The probable ancestor of the inverted in-line engine was the 40 h.p. Gregoire "G.Y.P." of 1910. Although this suggests an early interest in the potentialities of the inverted engine for aircraft applications, it did not then become established, probably because of lubrication difficulties. By 1929, however, progress in light aircraft design had reached a point where methods of improving the streamlining and of providing better visibility for the pilot were becoming an essential feature of design specifications.

The first attempts to meet these requirements aimed at sinking the upright engine further into the fuselage, but the possibilities in this direction were limited.

A new Mark of engine was introduced, the same in general detail as its predecessor, but incorporating certain alterations necessary to enable the cylinders to be inverted. The chief problem was that of providing a satisfactory lubricating system, which would prevent oil accumulating in the cylinders.

There were the two types of lubricating systems. The original wet sump was replaced by a separate oil tank, from which oil was pumped under pressure to the crankshaft. Drainage oil collected in the space surrounding the cylinder skirts and was returned to the oil tank through large pipes, one at each end of the crankcase, the appreciable extension of the cylinder skirts into the crankcase automatically preventing the bulk of the oil from entering the cylinders. Originally the return to the oil tank was by gravity, but in later versions dual scavenge pumps were provided. As finally produced the engine weighed 305 lb for the same rating as its predecessor, representing a slight increase in specific weight to 2·9 lb per horsepower.

In 1931 came the first uprating of the inverted engine and a subsequent version is shown in Fig. 3.

The new engine retained the principal features of the preceding design but its performance was improved by increasing the cylinder bore to 118mm, which, with the original stroke of 140mm, produced an output of 120 h.p. at 2100 r.p.m. normal and 130 h.p. at 2300 r.p.m. maximum on a capacity of 6·12 litres. The compression ratio was slightly increased to 5·25, but the weight remained at 305 lb, representing a further improvement to 2·54 lb per horsepower on normal rating. This engine was remarkably successful, ultimately achieving a life of 1500 hours between overhauls. The first experience of a crankshaft failure occurred when the engines were used with metal propellers for powering a twin-engined light transport aeroplane. The principal adverse influence was increased stress due to the appreciably heavier (metal) propeller, coupled with superimposed dynamic bending stresses caused by the passage of the propeller blade tips close to the sides of the (twin-engined) aeroplane fuselage.

While investigations were proceeding a few further failures occurred and it became necessary to modify the hub assembly. The hub itself was stiffened at the rear end and a differential taper was introduced between the hub bore and the crankshaft extension.

Six-Cylinder Engines

In 1933 there was a demand for a unit of about 200 h.p., which was satisfied by adding two cylinders of the existing size to produce a six-cylinder unit, thus retaining the small frontal area of the four-cylinder engine and the advantage of a cylinder assembly which had proved its reliability over a long period of bench and service testing.

The first of the six-cylinder series was rated at 185 h.p. at 2100 r.p.m. normal and 200 h.p. at 2350 r.p.m. maximum on 9·18 litres. The specific weight was 2·52 lb per horsepower on normal rating or practically the same as the four-cylinder unit from which it evolved. Probably the main contribution to this achievement was the use, for the first time in light aeroplane engine practice, of a magnesium alloy crankcase.

The first serious torsional vibration trouble was experienced at the start of this development when a crankshaft fractured in the journal between the two cylinders at the propeller end of the shaft.

As originally designed, the conventional firing sequence, 1–5–3–6–2–4, was used. Tests showed a large 4½th order critical zone of the fundamental (1-node) mode of torsional vibration in the region of 2200 r.p.m., i.e., between take-off and cruising speed. This result, coupled with the fact that the fracture had occurred in the nodal region of the vibratory system, where maximum dynamic torque is experienced, confirmed the suspicion that torsional vibration was at the root of the trouble. It was known from vibration theory that, by changing to firing sequence 1–2–4–6–5–3, the magnitude of the 4½th order would be reduced to at least one-third of its value with sequence 1–5–3–6–2–4. Torsiograph tests with the new sequence showed a 50 per cent reduction of total vibratory stress in the 4½th order critical zone and the revised arrangement was incorporated on production engines (Fig. 4).

In 1934 a racing version of this engine, equipped with two-pitch propellers and using special high-lift valve gear and a high-compression head, developed 230 h.p. at 2350 r.p.m.

Torsional Vibration

About 1936 considerable interest was being aroused in the aero-engine industry by the successful use, on an American radial engine, of a rotating pendulum vibration absorber.

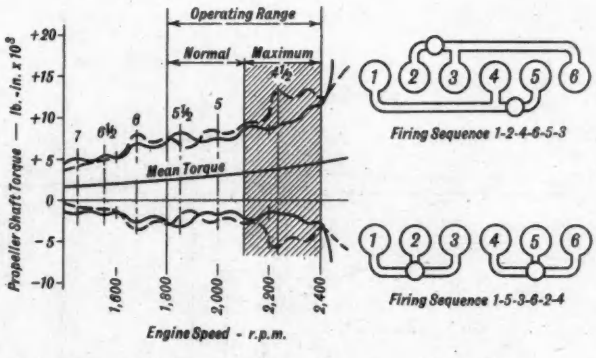


FIG. 4—*Influence of Firing Sequence on Torsional Vibration of Six-Cylinder Direct-Drive Engines*

The principal virtue of this device is that, unlike other vibration absorbers, it can be tuned to deal with a selected order of vibration over the whole speed range, enabling, for example, the powerful third order of a six-cylinder in-line engine to be eliminated at all speeds. It was appreciated, however, that the radial engine application was particularly favourable, since the very large crankweb counterweight, essential for primary balance, provided an effective pendulum mass.

Various expedients were investigated to

improve the absorber action, including trials with heavy metal (Tungsten) counterweights. Eventually, however, a compromise solution was obtained in which a series of steel absorber assemblies were carried on lugs forged on six of the twelve crankwebs, opposite each crankpin. Each assembly consisted of a pair of simple discs, one each side of the crankweb lug, both free to oscillate on a pin passing freely through holes bored in the discs and the lug.

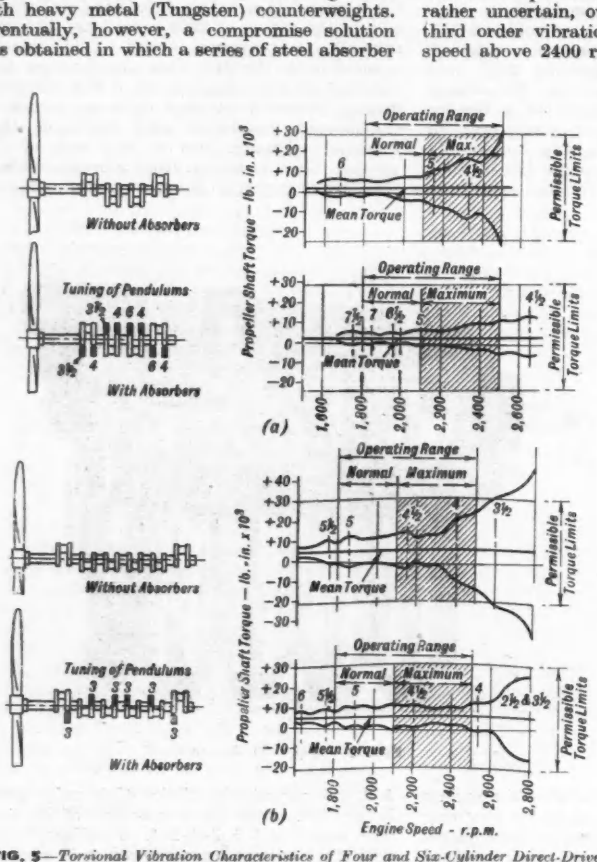
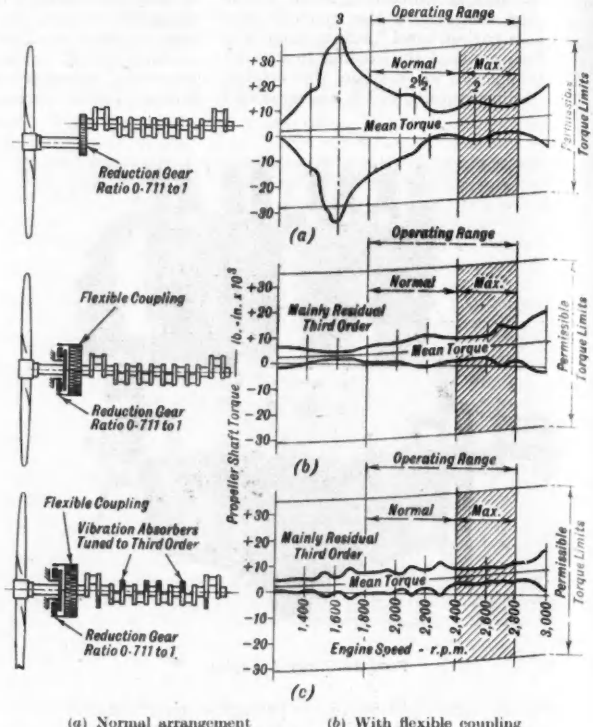


FIG. 5—*Torsional Vibration Characteristics of Four and Six-Cylinder Direct-Drive Engines, with and without Pendulum Vibration Absorbers*



(*a*) Normal arrangement (*b*) With flexible coupling
(*c*) With flexible coupling and absorbers

FIG. 7—*Torsional Vibration Characteristics of Six-Cylinder Geared Engine*

Searching for Higher Power

Towards the end of 1938, before the investigations on pendulum vibration absorbers were completed, development work on higher powered six-cylinder engines was initiated by bench-testing a production six-cylinder engine at a higher rating, obtained by increasing the compression ratio from 6·0 to 6·5 and the maximum speed from 2400 to 2500 r.p.m. Successful operation at this higher output was rather uncertain, owing to the growth of the third order vibration torque with increase of speed above 2400 r.p.m., and it was therefore not altogether surprising when the experimental work was terminated after 150 hours by a torsional fatigue failure of the crankshaft. It was, therefore, decided to increase the bore from 118mm to 120mm and the stroke from 140mm to 150mm to obtain an output of about 250 h.p. A careful design study revealed that these new dimensions could be accommodated in the same crankcase, but from experience on existing engines, where most crankshaft failures had commenced at the fillet radius on the underside of the crankpin, it was decided to increase the crankpin diameter from 50mm to 55mm, the journal diameter remaining at 60mm.

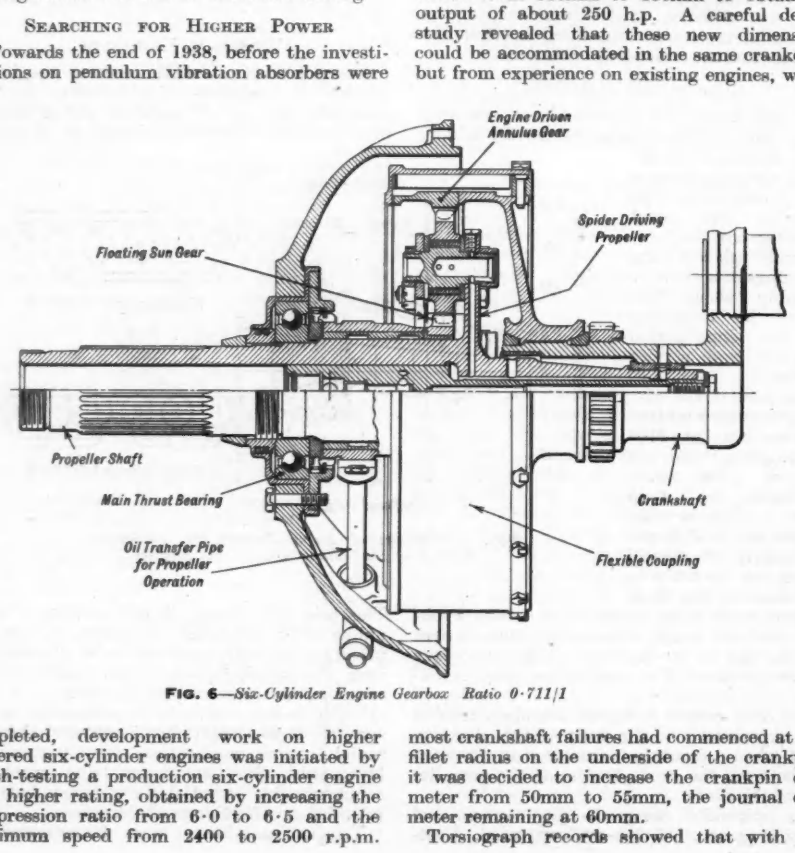


FIG. 6—*Six-Cylinder Engine Gearbox Ratio 0·711/1*

Torsiograph records showed that with the absorbers in action there was a considerable reduction of crankshaft vibration above a speed of 2200 r.p.m., the total vibration stress at the maximum speed of 2500 r.p.m. being about one-third the value without the absorbers (Fig. 5).

Post-War Development

An important policy underlying the series was to have as many interchangeable parts as possible. The complete series, which represents present-day practice, consists of two four-cylinder and three six-cylinder engines covering a range of take-off horsepowers from 160 to 380. The four-cylinder engines have a capacity of 6·78 litres and are direct-drive units, namely, a normally aspirated version developing 160 h.p. at 2500 r.p.m., and a supercharged version developing 207 h.p. at the same speed. The direct-drive six-cylinder engines, each of 10·18 litres capacity, are rated at 250 h.p. and 300 h.p. respectively at 2500 r.p.m. for take-off, the higher powered version being supercharged.

All these engines have the same compression ratio of 6·5 and in the supercharged engines the supercharger is driven from the rear end of the camshaft at 11·2 times engine speed, giving a boost pressure of +5 lb per square inch for take-off. The larger crankshaft enabled the direct-drive, normally aspirated engines, to be run successfully without vibration absorbers. Vibration absorbers were, however, found to be desirable on the more highly rated supercharged versions.

The First Production Six-Cylinder Geared Engine.—The fifth engine of the series is probably the most interesting from the point of view of engine dynamics. This six-cylinder engine, with a capacity of 10·18 litres, is basically similar to the supercharged direct-drive model, but is provided with a reduction gear to drive the propeller at 0·711 crankshaft speed and the rating is increased to 380 h.p. for take-off, attained by running the crankshaft at 3000 r.p.m., which, with the same supercharger ratio as the direct-drive engines, provides a boost of +7·5 lb per square inch. The supercharger is driven from the forward end of the crankshaft by a special flexible shaft passing through the hollow camshaft instead of being driven from the rear end of

the camshaft itself, as in the ungeared version. This was done to relieve the camshaft of torsional twist owing to the increased torque of the supercharger.

The connecting-rods were redesigned in forged steel, since it was found that aluminium alloy rods of the required strength could not be used without an appreciable increase of crankcase dimensions.

The main reduction gear, shown in Fig. 6, is a simple epicyclic assembly with fixed sun-wheel and engine-driven annulus, and it was decided to fit a "grid" spring flexible coupling between the crankshaft and the reduction gear annulus. This arrangement produced the required drop of fundamental frequency without complications from other modes, at the same time providing a neat overall assembly, which allowed the annulus gear to float on the coupling springs, thus permitting the load to be shared equally between five planet gears mounted on spindles attached to a spider on the propeller shaft. The fixed sun gear was anchored to the reduction gear housing through a toothed coupling to permit slight movements of the gear under load, desirable because the sun gear sleeve served as a transfer bearing for feeding oil to the propeller, and the necessary close fit made it undesirable that the assembly should be subject to any radial load.

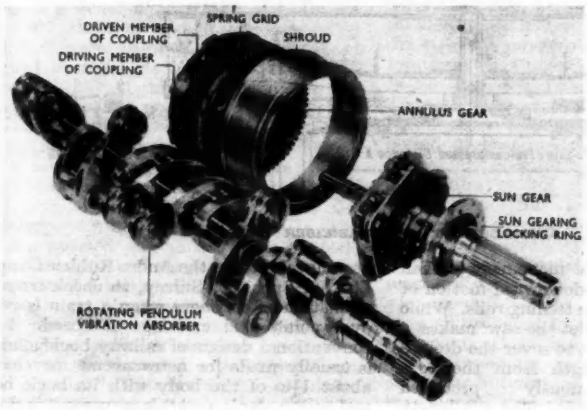


FIG. 8—*Crankshaft and Flexible Coupling Assembly for Six-Cylinder Geared Engine*

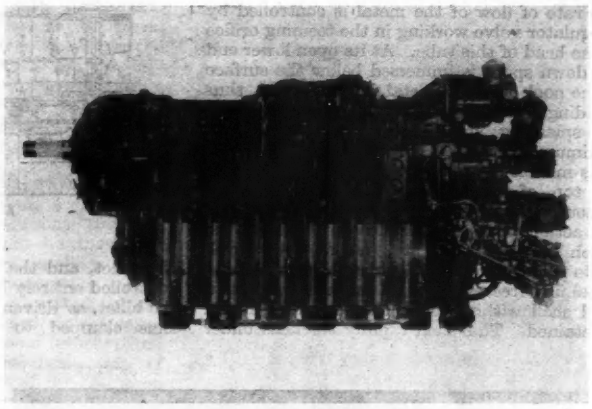


FIG. 9—*Gipsy Queen 70 Engine*

The torsional vibration characteristics of the geared engine are shown in Fig. 7, the fundamental torsional frequency being 4800 cycles per minute and giving a speed range from 2200 to 3000 r.p.m. clear of any significant critical zone. Owing to uncertainty regarding the severity of conditions when passing through the third order disturbance at 1600 r.p.m., it was considered prudent to fit third order pendulum vibration absorbers on six of the twelve crankwebs.

The complete crankshaft assembly, as originally produced, is shown in Fig. 8

Tests with the pendulum vibration absorbers locked demonstrated that the shock-absorbing characteristic of the coupling was adequate to maintain the vibratory torques well within permissible limits in passing through the third order critical zone. Future development therefore envisages the replacement of the pendulum absorbers by fixed balance weights, and one of the latest versions of the geared engine, incorporating this modification, has recently completed a type test giving approval for a take-off rating of 380 h.p. at 3000 r.p.m. and +7·5 lb per square inch boost, with a net dry weight of 685 lb. This represents a specific weight of only 1·8 lb per horsepower on take-off rating or 2 lb per horsepower on normal rating of 342 h.p. at 2700 r.p.m. In the case of the direct-drive engines, however, where the advantages of a flexible spring coupling are absent, pendulum absorbers will continue to be used, where necessary. One version of the engine is illustrated in Fig. 9.

General Developments

Cylinders and Cylinder Heads.—The four-bolt attachment of the cylinder and head to the crankcase, which provides easy access to the valves and seats, has been retained. The present satisfactory standard regularly withstands +10 lb per square inch boost in experimental running, achieved with deeper head castings in Y-alloy. Temperatures of 280 deg. Cent. in the region of the exhaust port are now permissible and a later development envisages cylinder heads with the valves disposed transversely instead of fore and aft, and a steel cylinder with bonded aluminium finning.

Cylinder Wear.—Honed finishes or phosphate treatments, by producing a matt, oil-retaining surface, were of great benefit in ensuring rapid ring-bedding and good oil control, but wear still appeared as a possible restriction upon overhaul life. Accordingly, the merits of nitriding and chromium-plating were investigated, with the result that a dense chrome treatment to a depth of 0·005in over one-third of the cylinder length at the combustion end has been adopted.

Piston Rings.—Gumming and groove-wear of piston rings required some investigation, resulting in the adoption of wedge-section rings for the supercharged engines, while in all types the thrust face of the ring is phosphate treated and machined with a 1 deg. taper to promote rapid bedding.

Exhaust Valves.—The solid austenitic steel valve proved inadequate and the first corrective measure was the use of sodium cooling. In addition, protective coatings were applied and, in general, alloys of the cobalt-chromium-tungsten (Stellite) type have proved more effective at the higher temperatures prevailing in an air-cooled engine than the chrome-nickel coatings so successful in liquid-cooled engines.

Inlet Valves.—The inlet valve material has been changed from a 12 per cent chromium stainless steel (S.62) to a plain austenitic steel (D.T.D. 49B) to overcome trouble due to cold pitting corrosion.

Valve Springs.—Service failures of valve springs were met by increasing the tempering temperature to a value (300 deg. Cent.) which was above the operating temperature (about 240 deg. Cent.) of the lower coils and by shot peening the wire to improve fatigue strength. Shot peening resulted in an improvement of about 50 per cent in fatigue strength.

Bearings.—Solid white-metal die-cast bearings 4mm thick were used in the earliest engines. Later these were replaced by steel-backed bearings lined with between 0·5mm and 1mm thickness of white metal, while the latest standard, as already mentioned, is a steel strip bearing of just over 1mm total thickness. White-metal lining of these strip bearings proved satisfactory for the normally aspirated engines and a lead-bronze lining with either a lead-indium or a lead-tin flash has given excellent service with unhardened crankpins and journals. The present standard is a lead-bronze lining with a lead-indium flash, and with adequate oil filtration crankshaft wear is negligible. The lead coating eliminates "picking-up" and promotes early bedding, while the infused indium enhances anti-friction properties, besides inhibiting corrosion.

Fuel Injection.—Investigations were initiated in 1939, which resulted in the introduction of a bulk fuel injection system for the supercharged engines of the post-war series. In this system fuel is injected into the supercharger impeller eye, allowing a closer control of fuel flows over a wider range of operating conditions than is possible with the conventional carburetter. Automatic variable-datum boost control is used on all supercharged engines. Other systems explored included high pressure head injection, which was particularly directed towards assessing the potentialities of safety fuel; low pressure head injection, and low pressure port injection. While these latter systems show advantages in some directions, the orthodox carburetter has remained the standard on the lower-powered engines.

Conclusion

From the first four-cylinder unit with a maximum piston speed of 1700ft per minute, developing 20 h.p. per cylinder or 18 h.p. per litre, the power output has steadily climbed until, in current engines, the specific output is over 63 h.p. per cylinder or 37 h.p. per litre at a maximum piston speed of nearly 3000ft per minute. The frontal area of the engine has remained about the same as for the earliest model, while the specific weight has been steadily reduced from over 4 lb to under 2 lb per horsepower. The specific weight in terms of cubic capacity has remained substantially unaltered at about 70 lb per litre.

Reliability.—Above all, one essential quality of the light aeroplane engine—reliability—has been kept well in mind throughout the years and to-day, as at the beginning, every new production type is the subject of constant review for means whereby its reliability can be improved as measured in terms of overhaul period.

In the field of piston-engine design there remains considerable scope for further development, particularly in satisfying the needs of improved types of light aeroplane. New or improved materials, better fuels and further advances in thermo-dynamic knowledge and the theory of vibration may result in increased performance, but through it all the aero engine designer must consider his components in relation to the lives depending upon them.

Luncheon to Mr. H. M. Spiers.—On Wednesday, April 4th, a luncheon was given at the Dorchester Hotel, London, to Mr. H. M. Spiers, editor of "Technical Data on Fuel." Sir Vincent de Ferranti, chairman of the British National Committee, World Power Conference, presided. Among those present was Sir Ernest Smith, chairman of the "Technical Data on Fuel" Committee. The luncheon was to mark twenty-three years' most successful editorship of this standard work by Mr. Spiers. In proposing a toast to Mr. Spiers, Sir Vincent de Ferranti announced that the first large impression of the fifth edition of "Technical Data on Fuel," published in September, 1950, was nearly exhausted, and that a second impression would be published in a few months' time.

Continuous Casting Machines for Brass

We have received particulars of a continuous casting machine for the production of brass billets, which has recently been put into operation at the Nechells, Birmingham, factory of James Booth and Co., Ltd. This plant, believed to be the first to operate on an industrial scale in the British brass industry, can be seen in the photograph reproduced on this page. The decision to adopt this method of production of the brass billets used for extrusion was based on the experience gained during several years' use of a similar machine installed in 1939 for casting the company's "Duralumin" aluminium alloys. Information was also available regarding the successful use of the method in casting brass in the United States.

The general outline of the process is now fairly well known, and in it molten brass is delivered from the melting furnaces in ladles transported by overhead cranes and is poured into a holding furnace or metal mixer at the top of the casting machine. The metal is teemed from the holding furnace continuously through a down spout of special alloy cast iron attached to the under surface of the furnace. The rate of flow of the metal is controlled by a regulator valve working in the teeming orifice at the head of this tube. At its open lower end the down spout is immersed below the surface of the pool of liquid metal in the mould, thus avoiding any open jet of metal, and so eliminating splashing and reducing oxidation to a minimum.

As molten metal is poured continuously into the top of the mould, solid metal is continuously withdrawn from its open bottom by the action of a pair of driven feeding rolls, which grip the billet at a rather lower level. In its passage downward through the mould the metal first freezes round its perimeter to form a solid shell within which the remaining liquid is retained. This shell rapidly thickens under the cooling action of the mould and eventually the whole cross section is solidified. The solidification may not occur, however, until the billet has passed out of the actual mould and into the region of supplementary cooling sprays which pour water on to the exposed billet surface below the mould before it enters the feeding rolls.

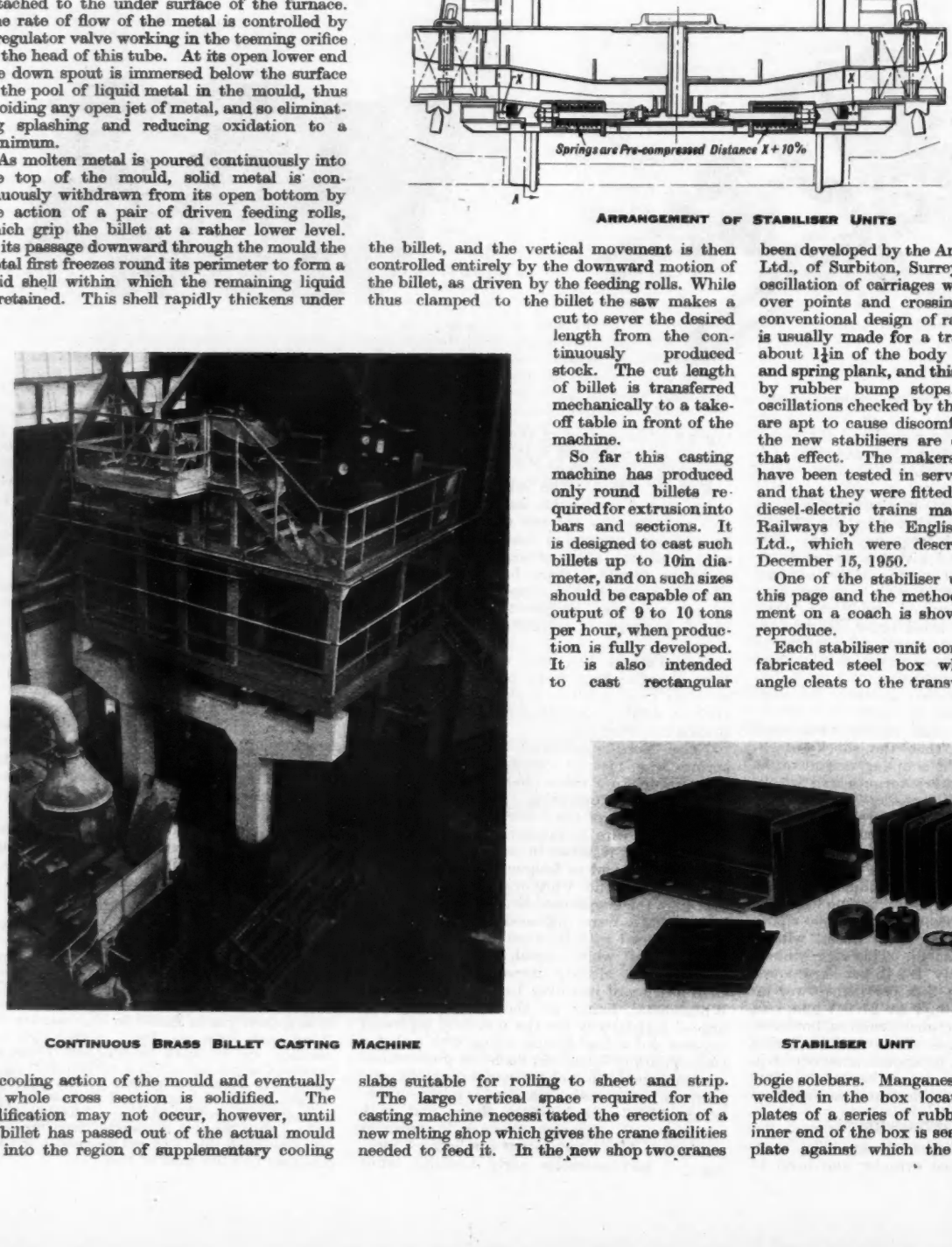
A special feature of the mould, which is peculiar to the Junghans-Rossi design of casting machine, of which this is an example, is that it is given a vertical reciprocating motion imparted by a cam. The mould travels downward at the same speed as the metal for the largest part of each cycle and then returns quickly to its upper position. This motion produces heat flow conditions in the thin wall of the water-cooled mould, which enable a higher rate of heat extraction to be attained than is possible in a stationary mould in which the hottest point, the liquid surface, is always at one level in the mould.

Below the feeding rolls is a cut-off saw, which slides as a complete unit on vertical columns, its weight being supported by chains passing over sprockets and carrying balance weights on their free ends. The sprockets can be driven to traverse the saw up or down and can be held by a brake in any position. The brake is released automatically as the vice of the saw closes on the billet, and the vertical movement is then controlled entirely by the downward motion of the billet, as driven by the feeding rolls. While thus clamped to the billet the saw makes a cut to sever the desired length from the continuously produced stock. The cut length of billet is transferred mechanically to a take-off table in front of the machine.

So far this casting machine has produced only round billets required for extrusion into bars and sections. It is designed to cast such billets up to 10in diameter, and on such sizes should be capable of an output of 9 to 10 tons per hour, when production is fully developed. It is also intended to cast rectangular slabs suitable for rolling to sheet and strip.

The large vertical space required for the casting machine necessitated the erection of a new melting shop which gives the crane facilities needed to feed it. In the new shop two cranes built by Herbert Morris, Ltd., each of 10 tons capacity, 46ft span, operate on a gantry 38ft above floor level. The crane capacity was provided to enable the holding furnace to be removed, if necessary, with a full charge of metal. It is of interest to note that the bridge structure of these cranes is built entirely in "Duralumin." The Ajax-Wyatt melting furnaces, supplied by the Electric Furnace Company, Ltd., are each of 350kW and are rated to melt 1·5 tons per hour.

The casting machine is operated under licence from, and was built to, the general designs of the Rossi Continuous Casting Company, of New York; the detailed design and the construction being carried out by the Loewy Engineering Company, Ltd., of Bournemouth.



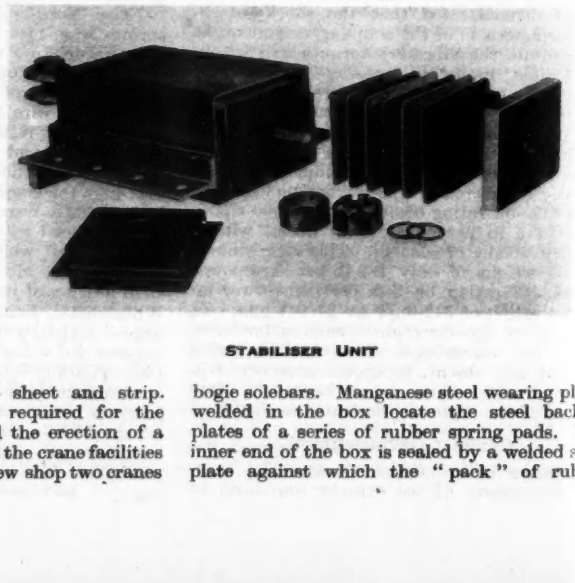
CONTINUOUS BRASS BILLET CASTING MACHINE

Carriage Bogie Stabiliser Units

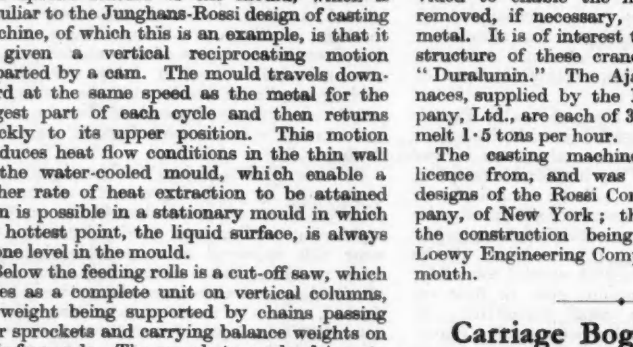
We have received particulars of a side stabiliser unit for railway bogies which has been developed by the Andre Rubber Company, Ltd., of Surbiton, Surrey, to check transverse oscillation of carriages when a train is passing over points and crossings at speed. In the conventional design of railway bogie allowance is usually made for a transverse movement of about 1¼in of the body with its bogie bolster and spring plank, and this movement is checked by rubber bump stops. Sudden transverse oscillations checked by these rubber bump stops are apt to cause discomfort to passengers and the new stabilisers are designed to overcome that effect. The makers state that the units have been tested in service with good results, and that they were fitted on the vehicles of the diesel-electric trains made for the Egyptian Railways by the English Electric Company, Ltd., which were described in our issue of December 15, 1950.

One of the stabiliser units is illustrated on this page and the method of fitting the equipment on a coach is shown in the drawing we reproduce.

Each stabiliser unit consists of a rectangular fabricated steel box which is attached by angle cleats to the transverse tie bar between bogie solebars. Manganese steel wearing plates welded in the box locate the steel backing plates of a series of rubber spring pads. The inner end of the box is sealed by a welded steel plate against which the "pack" of rubber



STABILISER UNIT



ARRANGEMENT OF STABILISER UNITS

spring units assembled inside the box is pre-compressed by means of the nuts on a link rod which passes through the centre holes of the units. As can be seen in the drawing the inner end of the link is formed as a yoke and is coupled by a pin to the movable spring plank and bolster of the bogie.

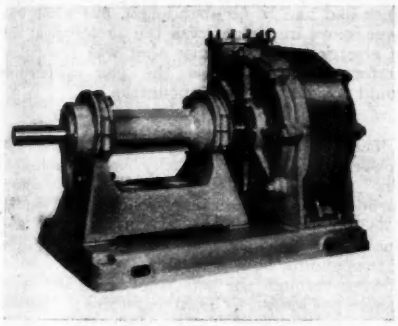
It will be appreciated that movement of the bogie bolster and spring plank in a transverse direction imparts a force on the opposite side of the motion and compresses the rubber spring units on that side. When the stabilisers are assembled they are precompressed an amount equal to the permitted side movement plus about 10 per cent. Thus, when the body of the coach surges to one side one set of rubber springs is further compressed and the opposite set is released to within 10 per cent of its pre-compression. On the return surge the energy stored in the rubber spring units controls the rate at which the body moves. In this way any sudden side movement of the body is controlled during the whole of its travel instead of suddenly by the bump stops after the initial movement.

A Rubber Lined Pump

To meet a demand for larger sizes in its rubber lined abrasion and corrosion-resisting pumps, Wilkinson Rubber Linatex, Ltd., of Camberley, Surrey, has introduced 10in and 12in pumps having nominal capacities of 2000 and 3000 gallons per minute respectively. These new pumps are each suitable for heads up to 120ft and can handle solids up to 2in cube.

The photograph reproduced below shows one of the 12in pumps, the design of which follows broadly that developed for the existing range of pumps, except that the volute casing is supported on the bed-plate by feet, instead of being fitted to a flange cast integral with the base, as in the smaller sizes.

All the internal surfaces of the pump are protected with "Linatex" rubber, except a renewable gland sleeve of stainless steel. The four blades of the shrouded impeller are made of solid "Linatex." Widely spaced heavy-duty, double-row Skefko roller bearings are fitted to



12IN RUBBER LINED PUMP

the high-tensile steel shaft of the pump, and the impeller retaining nut is machined from a stainless steel casting. This cast and machined nut is considered essential to prevent seizing of the thread, as the pumps will frequently be employed in coal washeries, power station boiler-houses, sand pits, &c., where acid water and dirty conditions are often encountered.

In common with all other units in this range, the new pumps have been designed to withstand the very severe conditions met with in mining. Each component can be quickly dismantled as "Linatex" is carried over all the joint faces to avoid necessity for the large number of closely pitched studs and nuts usually required to maintain a fluid-tight joint. A specially designed extracting tool is supplied for removing the rubber-covered impeller for which the normal slinging methods would be unsuitable.

We are informed that the first 12in pump has already been delivered to a large coal washery in the Coal Board's Northern Division, where it will be used on the main washery circuit.

American Engineering News

(From our American Correspondent)

Low-Temperature Working of Stainless Steels

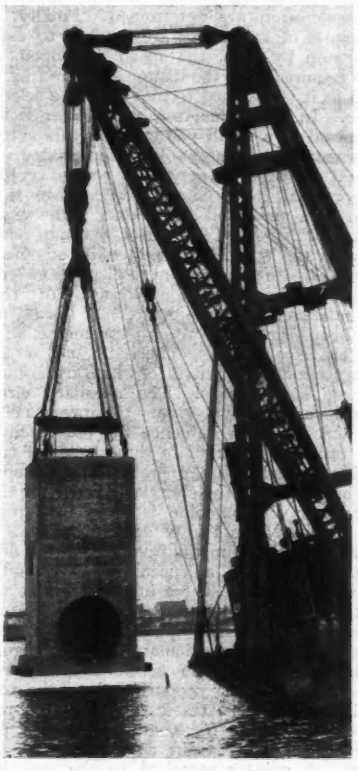
An unexpected result from routine tests—the presence of magnetism in a fractured piece of stainless steel—has led to a new process by means of which stainless steels can be made about 100 per cent harder than has been possible by conventional working procedures. Impact tests on cast stainless steels, which were being conducted at the temperature of liquid nitrogen (approximately —300 deg. Fah.), yielded a sample that, after having returned to room temperature, exhibited a strong magnetic effect near the point of fracture. Other samples broken at room temperature displayed none of this magnetism. Subsequent tests showed that temperature alone was not the cause. Apparently the increase in permeability had been caused by a combination of the severe plastic deformation due to the impact testing and the low temperature. Tests conducted with the broken impact samples showed that the hardness adjacent to the fracture had increased over that in the "as cast" condition by two to three times. This discovery became the basis for further intensive research on the effects of rolling and drawing at sub-zero temperatures, conducted jointly by the Crane Company and the Westinghouse Research Laboratories, of Pittsburgh, Pennsylvania. Some of the best results were obtained by a procedure consisting of a short period of heat-treatment at 2100 deg. Fah.; quenching in water, cooling to about —300 deg. Fah., rolling the metal while at that temperature, from $\frac{1}{4}$in to $\frac{1}{16}$in, and, finally, ageing for several hours at about 750 deg. Fah. Significantly, the highest hardness and strength values were obtained in those specimens rolled at the lowest temperature. Tensile strength, yield strength and hardness were all increased by this process, as compared with conventional rolling at room temperature. The increase in proportional limit was of particular interest as it proved to be more than double that obtained by rolling at room temperature. Torsional yield stress and fatigue strength were also increased by about 50 per cent. The process, as developed by the above-mentioned companies, is being referred to as "Zerolling."

Bureau of Reclamation Engineers in Northern Rhodesia

Two engineers on the staff of the Bureau of Reclamation have left Washington for Northern Rhodesia to assist in the development of water resources and irrigation schemes. The assignment of the engineers was made at the request of the Economic Co-operation Administration and the British Government, and it brings to a total of thirty-two the number of members of the staff of the Bureau who have been on foreign duty in various countries under E.C.A. or State Department programmes of technical assistance. The team which has left for Northern Rhodesia consists of Mr. Edgar E. Foster, a hydraulic engineer of Denver, Colorado, and Mr. Clarence M. Jackson, a constructional engineer of Arapaho, Nebraska. During the next eighteen months they will study the Kafue River flats at Mazabuka and, specifically, Mr. Foster will be expected to provide advice on the amount of water likely to become available in the area, and on the possibility of growing rice by using residual water from flood periods without any large-scale engineering works for water control. Mr. Jackson is expected to offer advice on the possibility of providing definite water control, such as the impounding of the Kafue flood waters at a dam behind Kafue Hook and the subsequent use of this water for the control of irrigation.

A Sewage Works Outfall Chamber

The accompanying engraving shows a reinforced concrete structure weighing 180 tons being lowered, by means of a floating derrick, into place on the bottom of the Reynolds Channel to serve as the outfall chamber for a new sewage treatment works at Bay Park, Long Island, New York. The works now under construction will serve an area of 41,000 acres with a present estimated population of 300,000. When they go into operation later this year, the treated effluent will flow into the outfall chamber through a 12,600ft line of 84in diameter reinforced concrete pipe, which is under construction at present. The heavy concrete structure illustrated, which has effluent escape openings at the centre of each side, has been designed to keep the pipe-line outlet from becoming clogged or otherwise damaged. The chamber is 29ft high, 15ft long and 13ft 6in wide and was built on a barge near the actual site. A joint of 84in diameter pipe is built into its base to serve as a connection with the pipe-line leading to it from the sewage works ashore. Except for the effluent escape openings and a manhole inspection entrance at the top, all its walls are of solid reinforced concrete, approximately 2ft thick. In placing the outfall chamber into position recently it was lowered from the 100ft long boom of the floating derrick until it came to rest on a cradle of three heavy timber pile bents at the bottom of an excavation, which had been dredged in the shoal water of the Reynolds Channel.



SEWAGE WORKS OUTFALL CHAMBER

Once underwater inspection showed that the chamber was resting evenly on its cradle, divers started to bolt the chamber to the pile bents. The illustration indicates the heavy timber runners which had been built into the bottom side of the chamber for this purpose. The top of the outfall chamber will always be exposed, a height of 6ft 6in being above the surface at mean high water. The next step in the construction project was to backfill the excavation around the chamber, firmly embedding the structure in the channel bottom. Divers then linked the intake joint of the chamber with the last sections of the 84in diameter outfall pipe-line. The laying of this pipe-line entailed the excavation of a trench 22ft below mean sea level, approximately 100ft wide at the top and 20ft wide at the bottom. Barge-mounted dredgers dug their own flotation as the work progressed across the marshland. The 84in reinforced concrete pipe was laid by divers in 32ft 3in lengths, each weighing 34 tons. Dredgers working behind the pipe crews backfilled the line as the sec-

tions were laid. The project was under the direction of the Public Works Commissioner of Nassau County, Long Island, the contractors being by the Merritt-Chapman and Scott Corporation, of New York City.

An Electro-Mechanical Train Performance Calculator

The Pennsylvania Railroad recently placed into service an electro-mechanical train performance calculator at Philadelphia. By means of measuring and recording instruments, this device quickly computes and records information required to determine the economics, schedules and appropriate tonnage ratings for various types of motive power. Such information was previously assembled from a large number of tedious step-by-step mathematical calculations, whereas the new machine performs and records the necessary calculations for a high-speed passenger train in actual train running time. The procedure generally followed to calculate the performance of a given train over a given route is first to assemble pertinent data relating to motive power, tractive effort, train resistance, effective track grade operating restrictions and scheduled stops. Next, train acceleration at any speed and the limitations on the use of acceleration are determined. Finally, the principles of mechanics are applied to calculate, step by step, the speed developed, the time required, and the distance covered by the train as it is assumed to move along a selected route. In this calculator, net acceleration is expressed as a small voltage. As this voltage is measured, it is mechanically integrated with respect to time to control a second voltage proportional to speed. Speed voltage is, in turn, measured and integrated with respect to time. The speed integrator, through relays, controls the speed of a motor to advance a chart at a rate proportional to distance covered. Basically the calculator consists of three self-balancing, potentiometer "Leeds and Northrup" graph-recording instruments, which are electrically interconnected, and a low-energy auxiliary circuit, all of which are mounted on two steel panels. The auxiliary circuit contains apparatus necessary to represent effective forces which influence the movement of the train and to simulate three types of train motion: acceleration, operation at fixed speed and braking. All the electrical energy required to operate the machine is supplied through two 3A fuses from a 110V lighting system.

The three instruments involved are an acceleration recorder, a speed recorder and a distance recorder. These instruments, as well as the auxiliary apparatus, were previously developed for other applications and have been adapted to the calculator with no changes in basic design. The acceleration recorder measures a voltage proportional to the total motive power and track acceleration forces, or to the braking force, and provides a permanent record of train acceleration at any time. A pointer attached to the recording pen carriage indicates instantaneous acceleration along the lower instrument scale, which is calibrated from minus 2·4 to plus 2·4 m.p.h. per second. A mechanical integrating device operates in conjunction with the acceleration measuring mechanism and moves a contact over a straight section of slide-wire, situated behind the upper instrument scale. This contact is attached to a pointer, which indicates speed on the upper instrument scale, calibrated from 0 to 120 m.p.h. The straight slide-wire transmits to the speed recorder a voltage proportional to speed. The speed recorder measures this voltage and provides a record of train speed at any time. A pointer associated with the pen indicates speed on a scale calibrated from 0 to 120 m.p.h. This instrument contains two retransmitting slide-wires and a mechanical integrating device, which are positioned by the speed measuring mechanism. One slide-wire transmits to the acceleration recorder a voltage proportional to acceleration; the other transmits to the distance recorder a voltage proportional to speed. An integrating device, through relays and cam-actuated contacts, regulates the speed of the special chart-drive motor in the distance recorder. The distance recorder measures speed and provides a permanent record of speed on a prepared chart, which represents the track. A curve-drawing pen represents the train. A pointer moving with the pen indicates speed along the right-hand section of the instrument scale, calibrated from 0 to 120 m.p.h. A solenoid-operated pen, situated under the left-hand section of the scale and actuated by a timing motor, provides a permanent record of time by drawing short, horizontal lines at five-minute intervals. The left-hand sections of the scale and the chart are ruled from 0 to 60 minutes. This portion of the chart is completed manually, to show time in hours and minutes at any location, following conclusion of the calculation. The special chart-drive motor advances the chart in steps of 0·02in for each 0·1 mile of calculated performance.

Prior to making a calculation, the known data have to be prepared and placed in the machine. The track information is plotted to scale on the speed distance portion of the chart in the distance recorder. It consists of effective track grades, equivalent acceleration values, speed restrictions, braking lines, required braking acceleration values, mileage designations, stations and interlockings. The train information is reduced to terms of net acceleration on level tangent track. This information is translated into proportional voltage by adjusting rheostats, most of which are connected between fixed positions along a slide-wire, which is positioned automatically by the speed-measuring mechanism. After the known data have been placed in the calculator, the power switch is turned on. Calculation and recording are fully automatic except for changes of track grade and for changes in type of motion. This information is supplied to the calculator by adjustment of a rheostat to regulate a voltage proportional to the acceleration produced by effective track grade (or proportional to the retardation required for braking) and by operation of a three-position switch to simulate type of motion. Progress of the speed trace on the prepared distance chart determines the nature and extent of each adjustment. One man can handle both adjustments without difficulty. He must, however, carefully follow the speed trace and other indications on the speed-distance chart. The train performance calculator has been used extensively by engineers of the Pennsylvania Railroad to analyse and to predetermine performance of diesel-electric, straight electric, and steam locomotives. It is particularly effective in making comparisons between different forms and sizes of motive power on the same train. No special allowances are necessary for track conditions, locomotive handling or equipment defects, the results being wholly dependent upon information supplied. A number of road tests under specified conditions have been confirmed with the calculator.

The Synchro-Cyclotron at the University of Chicago

After three and a half years have been spent on design and construction, satisfactory initial tests have been conducted on the large synchro-cyclotron at the University of Chicago. Deuterons, the nuclei of heavy hydrogen atoms, have been accelerated to energies of 250MeV, believed to be the highest energies ever to have been achieved artificially with such atomic particles. The next step will be an endeavour to focus a beam of protons. Ultimately, it is planned to accelerate protons to energies of the order of 450MeV, when the Chicago apparatus would become the most powerful accelerator of positive ions in the Western world.

NATIONAL SMOKE ABATEMENT SOCIETY.—Mr. Sydney N. Duguid has been elected chairman of the executive council of the National Smoke Abatement Society, in succession to the late Mr. Charles Gandy. He is chairman of the North-West Section of the Institute of Fuel.

French Engineering News

(From our French Correspondent)

French firms have obtained contracts to build a steel works at Chimbote in Peru. The works will be the second large steel installation built by French interests in South America; the first was a steel works in Colombia. Ores will be brought 900km for smelting at the new works. The cost of construction is estimated at 10 million dollars and the plant will take about two years to build.

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A contract for 13-ton tanks has been placed by the French Government. The tank, which is on the secret list, is said to be of great interest. From an industrial point of view, its interest lies in the employment it has given to a section of the heavy industry which was badly in need of work. The rate of orders, it is announced, will be kept up throughout 1952.

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The Lille Fair, which will be held at the end of April and the beginning of May, is expected to be better this year. The Fair buildings, which were very badly damaged during the war, have now been rebuilt. Exhibits at this year's Fair will include representative examples of products of the heavy industries, and for the first time the Ministry of Merchant Marine will have a stand showing shipbuilding materials.

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The development of French gas production and sales was recently outlined by Monsieur Kec, Vice-President of the Technical Association of the Gas Industry. Monsieur Kec said that in 1900 some 628 million cubic metres of gas were sold. By 1914 the figure increased to 1000 million, and to 1865 millions in 1930. In 1949 about 2546 million cubic metres of gas were sold. These figures were impressive, he pointed out, but nevertheless, Belgium, which is a small country, used about 680 million cubic metres of gas per year more than France. This could be explained by the growth of hydro-electric power. In 1951 the Gaz de France would allocate 7000 million francs to modernisation, which was, in Monsieur Kec's opinion, just about half the sum required. Many projects, including the installation of long-distance pipelines had had to be abandoned, but what was even more important was the preferential use of electricity not because that was the policy preferred, but because the gas authorities could not get sufficient apparatus.

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The 1950 production figures of the Genissiat power station have recently been published. The minimum daily production, with two turbo-alternator sets in service, is given as 1,383,000kWh, and the maximum daily production as 6,235,000kWh, with four sets. The corresponding figures for the amount of water flowing through the sets were from 197 cubic metres per second to 58 cubic metres per second for the minimum daily production and a maximum of 509 cubic metres per second for the maximum daily production. July was the best month of the year when 188,971,600kWh were generated, and January was the lowest with 66,288,800kWh.

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A new hydro-electric plant is being planned for Equatorial Africa. It will be at Djoué, about 6km from Brazzaville. The installed capacity of the plant has not as yet been decided, although a capital outlay of 1000 million francs is envisaged for the installation. It is hoped that work on the project will start shortly and that it will be completed by 1953.

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An increase in the price of steel is being considered by the French Government. The increase is expected to be between 30 and 40 per cent. It is reported that steel production in February fell badly. Pig iron production slumped from 931,000 tons to 824,000 tons, steel ingots from 1,043,000 tons to 945,000 tons, and sheet from 777,000 tons to 713,000 tons. The reduction has been attributed to insufficient coke deliveries from Germany.

Industrial and Labour Notes

The Coal Situation

Coal output in Great Britain in the week ended March 31st—which included the Easter holiday—amounted to 3,149,300 tons from the deep mines and 156,900 tons from opencast workings, giving a total of 3,306,200 tons. Last week total output was 4,650,200 tons, of which 210,900 tons came from opencast workings. In the first fourteen completed weeks of this year Britain's deep-mined output amounted to 55,240,100 tons, or 1,248,600 tons more than in the corresponding period of 1950. The mining manpower figures continue to show a steady improvement, the latest return by the Ministry of Fuel and Power indicating 702,800 on colliery books in the week ended March 31st, of whom 285,000 were face workers.

A delegate conference of the National Union of Mineworkers, which was held in London on Thursday of last week, endorsed a recommendation from the executive that the extension of working hours agreement should be continued for another year. This agreement, it may be recalled, provides for a Saturday shift or an additional half-hour a day. The conference decided, however, that the additional hours should be suspended during June, July and August. The suspension, it was asserted, would provide an essential period of relaxation from the working of extra shifts, without militating against the necessary increase in coal production required by the Government.

Non-Ferrous Metals Production

At the beginning of the week the Minister of Supply was asked in Parliament what steps were being taken to secure greater production of non-ferrous metals in Great Britain, in view of the prevailing scarcity of many of them. In a written reply, the Minister stated that some small lead and zinc mines were already operating and that others would be in the near future. The mining of wolfram was to be resumed in Devonshire and the production of magnesium in Government-owned plants was being restarted. But, the Minister added, non-ferrous metals produced from indigenous material could meet only a very small part of the country's total requirements.

Monopolies Commission Report

The second report of the Monopolies and Restrictive Practices Commission, which has just been published (H.M. Stationery Office, price 3s. 6d.), deals with the supply of cast-iron rainwater goods. The Commission, of which Sir Archibald Carter is the chairman, has found that the conditions to which the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948, applies, prevail in the supply of cast-iron rainwater goods in the United Kingdom.

The report says that more than 90 per cent of these goods are supplied by manufacturers belonging to the British Ironfounders' Association, which restricts competition by the operation of three "rainwater agreements" covering England and Wales, Scotland and Northern Ireland, respectively. It is also stated that, at the distribution stage, about two-thirds of the goods are supplied by merchants who are signatories to the "rainwater agreements" and whose own trade associations operate so as to restrict competition. Ways in which the agreements restrict competition are described in the report, which then goes on to observe that because of the "exclusive dealing" provisions, the arrangements are considered by the Commission to be against the public interest in various ways. Manufacturers and merchants who do not subscribe to the agreements, the Commission suggests, are excluded from a share in the great bulk of the trade and, owing to the operation of the minimum price agreement, the introduction of low-cost methods of production is retarded. Moreover, the report comments, there are no means by which savings in production or distribution costs resulting from bulk buying of standardised goods can be passed on to the consumer.

The Commission recommends that those concerned should amend their trading arrangements in such a way as to meet these objections. In particular, it suggests, there should be no discrimination by foundries about supplies or terms of supply against merchants who are not parties to the agreements or not members of trade associations, or against those who buy from non-members of the British Ironfounders' Association. The implementation of these recommendations, the Commission considers, would facilitate the speedy and unfettered development of newer methods of production.

National Income and Expenditure

A White Paper, entitled "National Income and Expenditure of the United Kingdom, 1946 to 1950," which was issued last Monday, quotes the value of the gross national product last year at £11,896,000,000, or 4½ per cent greater than in 1949. The gross national product, the White Paper says, is "a measure of the work done by the factors of production owned by the residents of the United Kingdom." About seven-eighths of the total consists of the output of a number of industries, which together may be described as covering the field of production and trade in a broad sense, the remainder being services of public authorities, domestic services, work for charities and other non-profit-making bodies and net income from abroad. Of the increased resources made available last year, about 70 per cent went to personal consumption and 30 per cent to the improvement of the United Kingdom foreign balance.

An analysis of the receipts which constitute the gross national product shows that all the main industrial groups have shared in the rise in the last two years, though by no means equally. The rate of growth has been greatest in manufacturing industry, public utilities and distribution. The national wage bill last year required £4,470,000,000, compared with £4,230,000,000 in 1949 and £4,025,000,000 in 1948. Last year's wage bill for the manufacturing industries reached a total of £2,150,000,000, compared with £1,990,000,000 in 1949 and £1,850,000,000 in 1948. In the manufacturing group classified as "engineering, shipbuilding and electrical goods," the wage bill last year took up £505,000,000. In 1949 it amounted to £470,000,000 and in 1948 to £447,000,000. Another point shown by the tables in the White Paper is that the division of the national income was almost the same in 1950 as in 1949. Wages took up 40 per cent, and salaries 22½ per cent; 15 per cent went to company profits and 4½ per cent to the profits of small traders.

During last year there was a slight decline in home investment, compared with 1949. The tables also indicate increased capital expenditure in the gas, electricity and shipping industries and a decline in the capital expenditure of coal mining, railways and air transport.

Taxation of Trade Profits

About two years ago the Chancellor of the Exchequer appointed a committee, under the chairmanship of Mr. J. Millard Tucker, K.C., "to inquire into the method of computing net trade profits for the purpose of charging them to income tax and to consider the question of the basis period to be taken in assessing the tax on the profits so ascertained; to inquire into the method of computing net profits for the purpose of charging them to profits tax, and to report upon alteration of the tax law, which may be desirable."

The report of the committee was issued at the end of last week, and the recommendations made in it are naturally of considerable interest to all branches of industry. Among the committee's principal recommendations are that depreciation allowances should be given for commercial buildings such as shops and offices; that business losses should be carried forward without time limit or spread back three years at the end of a business, and that, in the case of director-controlled companies remuneration up to £2500 a year should be allowed for each full-time working director, subject to the existing maximum limits.

The committee says, in its report, that, theoretically, it is not able to agree with the view that a proper system of computing profits must necessarily take into account changes in the value of money. Rejecting "revalorisation" schemes and schemes for a special replacement allowance for industry, the committee comments that, in essence, all such schemes amount to a proposal that a business should be relieved altogether from tax on some part of its true profits. The committee urges the Treasury to set up an independent body to which an association representing a particular industry could apply for a minimum rate of initial allowance to be prescribed in excess of a new suggested minimum of 60 per cent. This body, the report says, should be entitled to take into account both the price level of the plant and machinery in question and the importance of the industry to the national economy.

Congress of Empire Chambers of Commerce

The seventeenth Congress of Chambers of Commerce of the British Empire is to be held in London in June, under the patronage of H.M. the King. H.R.H. the Princess Elizabeth will open the congress in the Hall of the Grocers' Company on June 11th. The congress is organised by the Federation of Chambers of Commerce of the British Empire, of which Lord Llewellin is the president.

About 250 delegates from thirty-five countries of the Commonwealth and Empire are expected to attend and the wide range of subjects for discussion will be divided between five committees dealing with industry and commerce, constitutional and social questions, international payments, communications and defence, and the economic development of the Colonial Empire. Since the last congress was held in South Africa, in 1948, there have been considerable changes in the world situation vitally affecting the trade and industry of the Commonwealth and Empire. It is, therefore, believed that this opportunity for discussion of Empire industrial problems will be particularly valuable.

Iron and Steel Production

Figures issued by the British Iron and Steel Federation on Wednesday morning show that the production of steel ingots and castings in March averaged 318,200 tons a week. This indicated an annual output rate of 16,546,000 tons, compared with an annual rate of 17,147,000 tons, at which steel production was running in March, 1950. It should be remembered, however, that output in March this year was affected by the Easter holiday. In the first quarter of this year, steel output was at an average of 315,900 tons a week, or at an annual rate of 16,425,000 tons. In the first quarter of 1950, production was maintained at an annual rate of 16,679,000 tons. Pig iron output in March averaged 184,400 tons a week, representing an annual production rate of 9,572,000 tons. Taking the first quarter of the year, pig iron output was at an annual rate of 9,587,000 tons, compared with a rate of 9,677,000 tons in the first quarter of 1950.

In the current number of *Steel News*, published monthly by the British Iron and Steel Federation, attention is directed to the shortage of raw materials. The importance of maintaining scrap supplies is also stressed, it being pointed out that the weekly consumption of scrap for steel making in this country amounts to 200,000 tons.

Notes and Memoranda

Air and Water

THE INSTITUTE OF MARINE ENGINEERS.—At the annual general meeting of the Institute of Marine Engineers, S. F. Dorey, C.B.E., F.R.S., D.Sc., Wh.Ex., was elected President in succession to Sir A. Murray Stephen, B.A.

FREEDOM OF CLYDEBANK.—At a ceremony held on April 6th, the Freedom of Clydebank was conferred upon Sir Donald Skiffington, a director of John Brown and Co., Ltd., and who was for many years the shipyard manager of the Clydebank yard.

REINTRODUCTION OF SMALL POWER ENGINES.—Parsons Marine Engineering Company, Ltd., of Southampton, is to reintroduce the series "L" engine, which has been redesigned to give ¾ h.p. at 850–950 r.p.m. It is intended to exhibit the engine in the marine section of the Motor Show next October.

THE COLLEGE OF AERONAUTICS.—The Governors of the College of Aeronautics, Cranfield, Bedfordshire, announce the appointment of Air Marshal Sir Victor Goddard, K.C.B., to succeed Mr. E. F. Relf, C.B.E., F.R.S., F.R.Ae.S., as Principal of the College. Air Marshal Goddard will begin his duties on September 1st.

COASTAL SHIPPING ADVISORY COMMITTEE.—The Minister of Transport has been informed by the British Transport Commission that it has nominated Mr. D. Murray, Executive Officer (Mineral Traffic), Railway Executive, to the Coastal Shipping Advisory Committee, in place of Mr. John Elliot, who has resigned from the committee following his appointment as chairman of the Railway Executive.

THE "BRABAZON" AIRCRAFT.—In a written parliamentary reply, the Minister of Supply has recently stated that it is too early to say what will be done with the "Brabazon" aircraft after all information has been acquired from their design, construction and operational experience. The future of the aircraft, the Minister explained, would depend on the outcome of the experimental work and on the requirements at the time.

FUEL PROBLEMS IN THE ROYAL NAVY.—The Admiralty has set up a committee to study present and future fuel problems affecting the Royal Navy. Mr. R. C. Geddes is chairman of the committee, invitations to serve on which have been accepted by representatives of the Ministry of Fuel and Power and of the oil industry, and by Professor F. H. Garner, of Birmingham University, and Dr. C. M. Cawley, of the Department of Scientific and Industrial Research.

SHIP REPAIR WORK.—In his chairman's statement, circulated with the accounts of Swan, Hunter and Wigham Richardson, Ltd., Mr. J. W. Elliott calls attention to the importance of his company's ship repairing establishments on the Tyne and Clyde. He says that in the past twelve months ships repaired and docked numbered 331, aggregating 2,493,504 gross tons. In addition, repairs were carried out afloat to 235 ships, totalling 1,474,442 gross tons.

SURVEY OF THE SPEY VALLEY.—The Secretary of State for Scotland was asked in Parliament on April 10th if he would make a statement on the proposal to survey parts of the Spey Valley with a view to reclaiming land from flooding. He replied that the general purpose of the survey was to determine the best utilisation of all the land in the Spey Valley. Particular attention would be given to the possibility of reclaiming flooded areas and to the effect of such reclamation on the land utilisation programme.

Miscellanea

THE LATE MR. SIDNEY WOLFE.—We have learned with regret of the death of Mr. Sidney Wolfe, which occurred on April 3rd. Mr. Wolfe, who was in his eightieth year, was chairman and governing director of Wolf Electric Tools, Ltd., until his retirement recently on account of failing health. He founded the firm in 1900.

STEEL FOR AGRICULTURAL MACHINERY.—A written parliamentary reply by the Parliamentary Secretary to the Ministry of Supply states that the sheet steel allocation for the manufacture of agricultural tractors and machinery, in each of the first two quarters of this year, exceeds the allocation made in the corresponding quarters of 1950.

INDUSTRIAL FUEL EFFICIENCY.—The Ministry of Fuel and Power (London Region) has arranged a conference on "Industrial Fuel Efficiency," which is being held to-day, April 13th, at the Mansion House, London. The conference is under the chairmanship of Sir John Buchanan, chairman of the London and South-Eastern Regional Board for Industry.

LUTON INDUSTRIAL EXHIBITION.—The Corporation of Luton, Bedfordshire, is organising an exhibition, from June 16th to July 14th, which will be fully representative of the industrial life of the Borough. It is to be staged in Wardown Park, Luton, and the space occupied by trade stands is expected to be about 20,000 square feet. The exhibition represents Luton's contribution to the Festival of Britain, but, in addition, this year is the seventy-fifth anniversary of the town's incorporation as a borough, and a civic section of the exhibition will illustrate the development of Luton's local government and public services.

SYNTHETIC RESIN ADHESIVES.—A summer school on "The Technology of Synthetic Resin Adhesives" is being organised by Aero Research, Ltd., Duxford, near Cambridge, and will be held from September 23rd to 29th next. Accommodation for those attending is being reserved at St. Catharine's College, Cambridge. Most of the lectures will be given in Cambridge and the practical work and demonstrations in the programme will be carried out at the company's works at Duxford. The course of instruction is being designed to cover the use of synthetic resin adhesives in the woodworking industries, and their application to engineering, electrical manufacturing and other industries. The fee for the course is ten guineas, inclusive of accommodation, meals and transport, and applications for enrolment should be made to Aero Research, Ltd.

FESTIVAL EXHIBITIONS IN THE PROVINCES.—The travelling exhibition, which is being organised as part of the Festival of Britain, will be staged at the following four centres:—City Hall, Deansgate, Manchester, May 5th to 26th; Woodhouse Moor, Leeds, June 23rd to July 4th; Bingley Hall, Birmingham, August 4th to 25th, and Broad Marsh Nottingham, September 15th to October 6th. Although drawing on the subject matter of the South Bank exhibition in London, the travelling exhibition is to be quite individual, emphasis being given to industry and production. It will cover an area of more than 35,000 square feet, and is said to be the largest portable exhibition ever arranged. At Manchester and Birmingham, the exhibition will be shown in permanent buildings, but at Leeds and Nottingham it will be installed in a rigid-framed structure clad with approximately 100,000 square feet of canvas. The complete display, including its collection of 5000 exhibits, will be transported to each city by road.

A QUICK-ACTION NUT.—A useful type of quick-action nut which has many applications, particularly in temporary repair work, has been developed by Mr. C. Mancha-Bennett, of 7, Heath Rise, Putney Hill, S.W.15. Known as the "caged split nut," the device consists simply of a nut split in two halves and held together by a hexagonal tubular cage. When the nut is applied the two halves are held together on the bolt near the nut's final position on the face of the piece to be clamped and the cage slipped over to hold them together. The nut is then tightened in the usual way with a spanner which fits over the cage. A particular advantage of the new nut is that any length of bolt can be used and, as the nut can be applied close to its final position without necessity for screwing all the way down the bolt, an appreciable amount of time can be saved. Further, if the top threads of a bolt have been damaged, the nut can be applied below the damaged portion. We are informed that nuts and cages down to 5 B.A. have been used by the designer.

SCHOLARSHIPS IN THE U.S.A.—The Ministry of Education has announced that, with the aim of contributing to industrial productivity in this country, thirty-five post-graduate scholarships are to be awarded in 1951 for the study of technology and management at selected universities or technological institutes and in industrial undertakings in the U.S.A. The cost of these awards will be met from funds provided by the American Economic Co-operation Administration. The awards, which will normally be tenable for a period of one year, will be open to students who hold good honours degrees in either pure science or technology, who have had at least two years' industrial experience and who are now working in industry or research associations or are teaching in universities or technical colleges. The scholarships will provide for tuition fees, books and travelling expenses in the U.S.A., and suitable maintenance allowances. The cost of the return passage to the U.S.A. will be met from public funds. Successful candidates will be expected to leave for the U.S.A. early in September, 1951. Full details of the scholarships may be obtained from the Ministry of Education, Curzon Street House, Curzon Street, London, W.1. Applications must be made by April 30th.

Personal and Business

THE ANGLO-AMERICAN OIL COMPANY, Ltd., states that its name has been changed to Esso Petroleum Company, Ltd.

FIBREGLASS, Ltd., Ravenhead, St. Helens, Lancs, announces that Mr. C. H. Notton, general sales manager, has been appointed a director.

THE BRITISH ELECTRICITY AUTHORITY states that Mr. J. Shepherd and Mr. C. E. Pugh have been appointed generation engineers (construction) in the North-Western Division.

MR. GEORGE KEATLEY has retired from the post of works manager of Dunlop Rim and Wheel Company, Ltd., Foleshill, Coventry, after forty years in the company's service.

MR. ARNOLD BAILEY, A.M.I.C.E., and Mr. Stanley Gleaves, M.I.Struct.E., have been taken into the partnership of C. S. Allott and Son, consulting engineers, North Parade, St. Mary's Parsonage, Manchester, 3.

J. H. FENNER AND CO., Ltd., announces that work has now begun on the extension to its main factory at Marfleet, Hull. The company also announces the opening of an additional branch at 95, High Street, Stoke-on-Trent, under the management of Mr. S. Parker.

THE SHELL PETROLEUM COMPANY, Ltd., announces the retirement of Mr. I. Lubbock, M.I.Mech.E., F.Inst.F., who has had charge of the internal combustion turbine section. For many years Mr. Lubbock was head of the company's fuel oil technical department.

THE ENGLISH ELECTRIC COMPANY, Ltd., states that Mr. Robert Johnson has been appointed assistant manager and Mr. Malcolm Logan, press relations officer, in the publicity department, 24, Gillingham Street, London, S.W.1. Mr. Peter Scott continues as manager of the department.

MR. C. A. SMILES, A.M.I.E.E., has relinquished on account of ill-health the position of manager of the South Wales territory of the English Electric Company, Ltd. His services will continue to be available to the company in an advisory capacity. Mr. Wood, of the company's Cardiff office, has succeeded Mr. Smiles as area manager.

Contracts

BURNTISLAND SHIPBUILDING COMPANY, Ltd., have received from the British Electricity Authority an order for three colliers each of 4600 tons deadweight and propelled by triple-expansion machinery supplied by North-Eastern Marine Engineering Company (1938), Ltd. The ships will be built by Hall, Russell and Co., Ltd.

VICKERS-ARMSTRONGS, Ltd., have received from the Union Steam Ship Company of New Zealand, Ltd., an order for a new twin-screw passenger ship for service between Lyttelton and Wellington. The vessel will have a displacement of 7090 tons, carry 970 passengers, and be fitted with B.T.H. turbo-electric machinery of 13,000 s.h.p. to give a speed of 21 knots.

HALL, RUSSELL AND CO., Ltd., are to build for Associated Humber Lines two motor cargo liners, each of 1100 tons deadweight with Polar diesel propelling machinery of 2400 b.h.p. constructed by John G. Kincaid and Co., Ltd. Another order received is for a tug, for Australian Steamships Proprietary, Ltd., propelled by a triple-expansion engine of 1320 i.h.p., giving 11¼ knots free speed.

Launches and Trial Trips

CELIA B, water tender; built by Philip and Son, Ltd., for the Falmouth Corporation; length 52ft, breadth 15ft, depth 6ft 4in, capacity 50 tons of fresh water; Gardner engine, 72 b.h.p. at 1200 r.p.m. Launch, April 3rd.

VANJA, motor tanker; built by the Furness Shipbuilding Company, Ltd., for Skibsaktieselskapet "Norheim," Oslo; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,800 tons; Hawthorn-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 115 r.p.m., 14 knots. Launch, April 5th.

Catalogues

BLAW-KNOX, Ltd., Clifton House, Euston Road, London, N.W.1.—Catalogue No. 103, "Dewatering Equipment"; catalogue No. 104, "'BK-Fifty' Excavator"; publication No. BK 134, "Hydraulic Angledozers for Caterpillar Tractors"; publication No. BK 137, "Hydraulic Angledozers for Fowler Tractors"; publication No. BK 133, "'Rex' 2 Cubic Yard High Discharge Motomixer."

British Patent Specifications

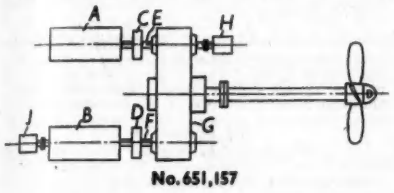
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

MARINE ENGINEERING

651,157. June 7, 1948.—MARINE ENGINE PLANT, Kaj Edvard Hansen, of No. 48, Blomstervænget, Lyngby, Denmark.

This invention relates to a marine engine plant employing as the main power engine for normal ahead running one or more gas turbines, which, through reduction gearing, drive one or more screw propellers. In the drawing, *A* and *B* represent gas turbines which through releasable, preferably magnetic, couplings *C* and *D* drive the fast-running shafts *E* and *F*, respectively, in a reduction gear *G*, the slowly revolving shaft of which is coupled directly to a shaft carrying a propeller with fixed blades. To one of the fast-running shafts *E* of the gear an electromotor *H* is coupled, and to one gas turbine shaft an electrical generator *J* is coupled. During



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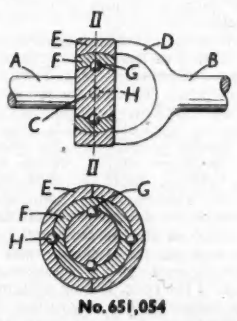
normal ahead working the propeller is driven mechanically through the reduction gear *G* by both gas turbines, the couplings *C* and *D* being engaged, and the motor *H* and the generator *J* being driven idle or disengaged for the avoidance of ventilation losses. During astern work or manœuvring the couplings *C* and *D* are disengaged, and the turbine *A* is stopped or made to run idle, while the turbine *B* drives the generator *J*. This supplies current for the motor which, through the shaft *E* of the reduction gear, drives the propeller ahead or astern. If the couplings and the electromotor are provided with remote control, all the functions of manœuvring can be performed from a manœuvring place in the engine-room or on the captain's bridge. The motor may also be used for starting the turbines by a suitable adjustment of the couplings *C* and *D* and the direction of rotation of the motor. During this function the motor must be supplied with current from another source, preferably one or more generators in the auxiliary machinery.—*March* 14, 1951.

MISCELLANEOUS

651,054. September 2, 1948.—UNIVERSAL JOINTS, Karl Eugene Nicolaus Kalstrom, of 5, Sven Rinmansgatan, Stockholm.

The drawing shows a sectional view of two shaft ends connected to each other by means of the universal joint which is the subject of this specification and a cross section along the line *II—II*. Of the two shaft ends to be connected, one, *A*, has a ball-shaped body *C* having a part-spherical outer surface. The other shaft end *B* has shanks *D* which carry a ring *E* with an inner part-spherical bearing surface. Between the ring *E* and the body *C* is a ring *F*, which has an outer part-spherical bearing surface



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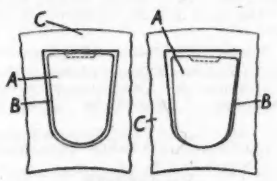
conforming with the inner bearing surface of the ring *E*, and with an inner bearing surface conforming with the outer bearing surface of the ball body. All of the bearing surfaces are concentric with one another and bear directly against one another in their respective pairs. A pivot axle is thus provided for each pair of co-operating bearing surfaces. The two pivot axles are disposed at right angles to each other in substantially the same manner as in a cardan joint. One pivot axle is formed by a pair of diametrically opposed balls *G*, which are located in recesses formed in the co-operating pair of bearing surfaces on the ball-shaped end *C* and ring *F*. In a corresponding manner the other pivot axle is formed by a pair of balls *H* located in recesses in the co-operating pair of bearing surfaces on the inner and outer rings *F* and *E*.—*March* 7, 1951.

650,817. September 27, 1947.—ROLLER BEARINGS, British Timken, Ltd., of 65, Cheston Road, Aston, Birmingham, 7 (*Inventor, David McNicoll*).

In the tapered roller bearing described, the small ends of the rollers have a convex rounded contour, and the small ends of the cage pockets are formed as segments of a hollow spheroid with a radius larger than the radius of the roller ends. The accompanying drawings show a diagrammatic view of a roller and cage pocket in accordance with the invention and illustrate a loaded roller lying symmetrically in the pocket to the right. A similar diagrammatic view is given showing the position taken by the roller when it is unloaded and



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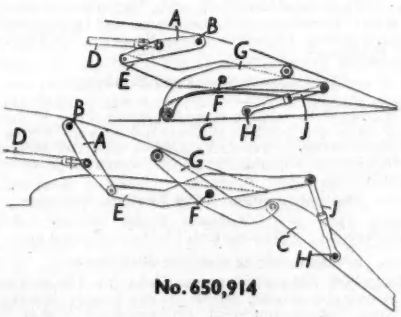
skews in the pocket. As shown, the small end of the roller *A* being made spheroidal, and the small end of the pocket *B* of the cage *C* being formed as a segment of a hollow spheroid with a radius larger than the radius of the roller end. It will be seen that when the unloaded roller skews in the pocket the contacting surfaces of the roller and cage are spheroidal with a predetermined degree of conformity, so that, at the point of contact the specific pressure is maintained as low as possible, and the tendency to wear a step in the side of the cage at the point of contact is reduced by virtue of the reduced contact pressure. Also, the righting moment exerted by the reaction of the cage on the roller at the point of contact is increased by bringing that point of contact as far away as possible from the centre of skewing. Further, the form given to the small ends of the cage pockets and rollers results in an improvement in the centring effect of the cage on the rollers, while in the event of the roller dropping right down into the bottom of the pocket while still spinning, friction between it and the cage is kept low by reason of the spheroidal form and the degree of conformity of the roller end and the cage pocket.—*March* 7, 1951.

AERONAUTICAL ENGINEERING

650,914. August 24, 1948.—FLAP MECHANISM FOR AIRCRAFT, The Fairey Aviation Company, Ltd., of North Hyde Road, Hayes, Middlesex (*Inventor, George Parker*).

In this flap mechanism for an aircraft the flap and its linkage are normally housed within the wing, so avoiding any projections which would interfere with the flow of air around the trailing edge. Referring to the drawings, a wing has a recess at the rear of its under surface. The lever



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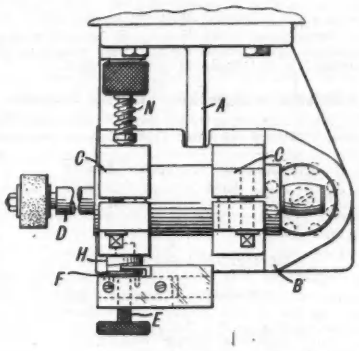
A is pivoted at its upper end *B* to the wing structure just below the upper surface of the wing and near the forward end of the recess in which the flap *C* is housed. The length of the lever is approximately equal to the thickness of the wing at this point. The lever has the rear end of an operating rod *D* pivotally secured midway along its length, through which it can be pivoted through an angle of about 120 deg. At the lower end of the lever is pivoted a slightly curved beam link *E*, pivotally connected at *F* with the mid-point of a forward link *G*, the upper end of which is pivoted to the wing just below the upper surface.

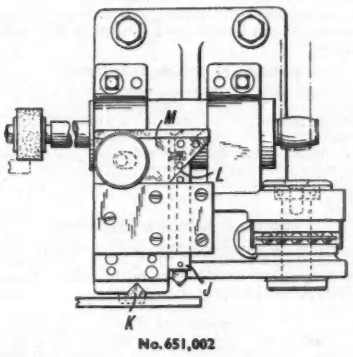
The lower end of the forward link is pivoted to the leading edge of the flap and at *H* there is pivoted the lower end of a rear link *J*, the other end of which is pivoted to the rear end of the beam link. During normal flight the linkage is housed in the recess in the wing, together with the flap and the linkage. When the flap is to be actuated, the operating rod is moved to swing the lever *A* rearwards, and the forward link *G* swings correspondingly, so moving the beam link and the flap rearwards and downwards out of the recess. Towards the end of the motion the forward link begins to move rearward and upward, so tilting the flap about its pivot with the rear link so that its trailing edge moves downward.—*March* 7, 1951.

MACHINE TOOLS

651,002. September 9, 1948.—INTERNAL GRINDING MACHINES, Guest, Keen and Nettlefolds (Midlands), Ltd., of London Works, Smethwick (*Inventor: Ernest Dickinson*).

The unit consists of a bracket *A* secured to the slide or carriage which normally carries the tool spindle. Pivotally mounted on the bracket is the body *B*, the upper part of which is provided with one or a pair of split blocks *C* and *C* in which are mounted horizontal bearings for the tool spindle *D* which has a driving pulley at one end. The centre of the pulley is directly over the axis of the pivot by which the body is attached to the bracket, so that the drive will not be affected by pivotal movements of the body. In the forward part of the vertical wall of the bracket is a screw *E* turned by a handwheel. This screw at its rear end bears upon a plate *F*. Between this plate and the side of the body are a body-displacing cam and a co-operating plate element *H*. The cam is mounted for horizontal movement at the back of the bracket, and the plate is fixed to the side of the body. The





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arrangement is such that the cam can be moved in an endwise direction to pivot and the body displaces the tool spindle in a transverse direction. This pivotal action is produced by a vertical sliding plunger *J* in the wall of the bracket, and having its lower end, of V-shape. This plunger is reciprocated by a V-shaped workholder cam *K* fixed to a plate adjustably mounted on the reciprocating workholder unit. The upper end of the plunger is provided with an incline *L* which engages an abutting incline at the end of a sliding plate *M*, which is mechanically connected to the sliding body-displacing cam. The arrangement is such that each time the V-shaped workholder cam *K*, moving with the workholder, passes under the lower end of the plunger *J*, the sliding plate *M* is moved in an endwise direction and causes the body-displacing cam to slide and either move the body backwards and forwards under the pressure of a spring plunger *N* between the rear wall of the bracket and the back of the lever arm. The grinding

wheel is mounted in the end of the tool spindle, and a dial indicator (not shown in the drawings) may be provided upon a bracket on the rear wall of the main bracket, this dial indicator having a member engaging with a suitable part of the body. In operation, the body is allowed to move to a position in which the axis of the tool spindle is parallel to the axis of the chuck carrying the work, and the slide carrying the body can be adjusted at right angles to the axis of the tool spindle to bring the tool spindle into the correct position in relation to the hole in the workpiece. This position may be set by placing a finished workpiece in the workholder. The finished workpiece can then be removed and a workpiece to be ground can then be placed in the chuck. The body is then adjusted by the handwheel of *E*, without moving the slide or carriage to bring the tool into a position enabling it to clear the wall of the hole in the workpiece. When the work and wheel are in a position in which the wheel extends through the hole, the hand screw is turned back, allowing the wheel to move until it engages the surface to be ground. Grinding can then proceed, using only the handwheel, until the dial indicator registers the position which it registered when a finished workpiece was mounted in the machine and engaged by the tool. Gauging is unnecessary until the dial indicator has almost reached the said position, so that there is a substantial saving of time in production. As the workholder reciprocates the tool is moved away from the surface to be ground just before the tool leaves the hole and just before it enters the hole. This operation is effected automatically by the workholder cam, which reciprocates with the workholder.—*March* 7, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

To-day, April 13*th.*—CREWE BRANCH: Crewe Arms Hotel, Crewe, "Battery Vehicles," R. D. Morgan, 7.30 p.m.

Illuminating Engineering Society

Fri., April 20*th.*—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, Discussion on "Street Lighting," E. Stroud and P. Crawford Sugg, 6 p.m.

Incorporated Plant Engineers

Tues., April 17*th.*—GLASGOW BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "The Construction of the Modern Oil Refinery," W. M. Greenhorn, 7 p.m.

Wed., April 18*th.*—WESTERN BRANCH: Grand Hotel, Bristol, Ten-Minute Talks by Members, 7.15 p.m.

Thurs., April 19*th.*—LIVERPOOL AND N. WALES BRANCH: Radiant House, Bold Street, Liverpool, Brains Trust, 7 p.m.

Institute of British Foundrymen

Tues., April 17*th.*—COVENTRY AND DISTRICT STUDENTS' SECTION: Technical College, Coventry, Annual General Meeting, Followed by a Brains Trust, 7.15 p.m.

Wed., April 18*th.*—BIRMINGHAM AND W. MIDLANDS BRANCH, STUDENTS' SECTION: Technical College, Dudley, "Moulding and Scrap Control," L. Clarke, 7 p.m.

Institute of Economic Engineering

Fri., April 20*th.*—Engineers Club, Albert Square, Manchester, Speaker, G. H. Jolly, 7.30 p.m.—The Greyhound Hotel, Croydon, "Progress Control," J. Bailey, 7.30 p.m.

Institute of Fuel

Tues., April 17*th.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "Production of Town Gas from Weakly-Baking Coals," J. G. King, 5.30 p.m.

Institute of Industrial Supervisors

Thurs., April 19*th.*—ROTHERHAM SECTION: College of Technology, Howard Street, Rotherham, "Works Information and the Supervisor," C. A. H. Owen, 7.30 p.m.——COVENTRY SECTION: Geisha Cafe, Hertford Street, Coventry, "Production Planning and Shop Loading," J. Ball, 7.30 p.m.——BRISTOL SECTION: Central Hall, Oldmarket, Bristol, "The Foreman and the Personnel Department," C. Broadhead, 7.30 p.m.

Institute of Physics

To-day, April 13*th.*—Ashorne Hill, Leamington Spa, X-Ray Analysis Group, Spring Conference, "The Texture and Structure of Metals."

Institute of Refrigeration

Thurs., April 19*th.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "Some Considerations on the Heat Pump," P. B. H. Brown, 5.30 p.m.

Institute of Road Transport Engineers

To-day, April 13*th.*—S. WALES GROUP: Institute of Engineers, Park Place, Cardiff, Open Discussion Meeting, 7 p.m.

Mon., April 16*th.*—MIDLANDS CENTRE: Crown Inn, Broad Street, Birmingham, "The Use of Lightweight Sandwich Materials in the Construction of Road Transport Vehicles," F. C. Lynam, 7.30 p.m.——SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, Annual General Meeting, 7.30 p.m.

Wed., April 18*th.*—N.W. CENTRE: Engineers Club, Albert Square, Manchester, Annual General Meeting, "Welding in Vehicle Maintenance and Repair," G. Mackenzie Junner, 7 p.m.

Thurs., April 19*th.*—LONDON CENTRE: Central Hall, Broadway, Westminster, S.W.1, "Trends in Vehicle Design—with Particular Reference to the Commercial Motor Show, 1950," P. M. A. Thomas, 6.30 p.m.——N.E. CENTRE: Hotel Metropole, Leeds, Annual General Meeting, 7 p.m.

Institution of Chemical Engineers

To-day, to Sun., April 13*th to* 15*th.*—Nutford House, Brown Street, London, W.1, 1951 Convention, "Chemical Engineering—Opportunities in Specific Industries."

Institution of Civil Engineers

Tues., April 17*th.*—Great George Street, Westminster, S.W.1, "Dredging and Reclamation," E. D. Kalis, 5.30 p.m.

Institution of Electrical Engineers

To-day, April 13*th.*—Savoy Place, Victoria Embankment, W.C.2, Discussion on "The Presentation of Laboratory Experiments," opened by G. F. Freeman, 6 p.m.

Mon., April 16*th.*—Savoy Place, Victoria Embankment, W.C.2, Discussion on "Public Lighting," opened by E. H. Jesty, 5.30 p.m.

Tues., April 17*th.*—MEASUREMENTS SECTION: Savoy Place, Victoria Embankment, W.C.2, Discussion on "Humidity Measurement and Control," opened by L. Hartshorn and H. S. Gregory, 5.30 p.m.——N. MIDLAND CENTRE: 24, Aire Street, Leeds, 1, "The Dimming of Low Pressure Discharge Lamps," C. W. Williams, 6.30 p.m.——SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "A Review of Research in Electricity Supply," C. W. Marshall, 7 p.m.

Fri., April 20*th.*—N.E. STUDENTS' SECTION: King's College, Newcastle upon Tyne, Annual General Meeting and Film Show, 6.30 p.m.——N.E. CENTRE: City Hall, Newcastle upon Tyne, "Lamps and Lighting—A Record of Industrial Research," L. J. Davies, 6.15 p.m.

Institution of Heating and Ventilating Engineers

Thurs., April 19*th.*—BIRMINGHAM AND DISTRICT SECTION: Imperial Hotel, Temple Street, Birmingham, "The Sunshine Problem in Air Conditioning," N. S. Billington, 6.30 p.m.

Institution of Locomotive Engineers

Wed., April 18*th.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "Practice and Trend in Development of Diesel Engines, with Particular Reference to Traction," G. Jendrassik, 5.30 p.m.

Institution of Mechanical Engineers

To-day, April 13*th.*—Storey's Gate, St. James's Park, S.W.1, "Steam Piping for High Pressures and High Temperatures," R. W. Bailey, 5.30 p.m.

Mon., April 16*th.*—MIDLAND BRANCH, GRADUATES' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 7 p.m.

Wed., April 18*th.*—SOUTHERN BRANCH, GRADUATES' SECTION: Municipal College, Portsmouth, Annual General Meeting, 7 p.m.

Thurs., April 19*th.*—E. MIDLANDS BRANCH, PROVISIONAL GRADUATES' SECTION: School of Art, Green Lane, Derby, Meeting followed by three films, 7.15 p.m.——MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on "Education and Training in Engineering Management," opened by H. G. Nelson, 6 p.m.

Fri., April 20*th.*—Storey's Gate, St. James's Park, S.W.1, Discussion on "The Design and Development of the Twin Centaurus Power Plant for the Bristol 'Brabazon,'" J. L. Norton, 5.30 p.m.

Institution of Mining and Metallurgy

Thurs., April 19*th.*—Geological Society, Burlington House, W.1, "Chromographic Contact Print Method of Examining Metallic Minerals and its Applications," David Williams and F. M. Nakhla, 5.15 p.m. (following Special General Meeting of Corporate Members at 5 p.m.)

Institution of Post Office Electrical Engineers

Wed., April 18*th.*—Waterloo Bridge House, S.E.1, "Training for Management," D. G. Dafforn, 5 p.m.

Institution of Production Engineers

Wed., April 18*th.*—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Measurement of Productivity," Walter C. Puckey, 7 p.m.——MANCHESTER GRADUATE SECTION: College of Technology, Sackville Street, Manchester, "Production of Electric Motors," F. E. Beake, 7.15 p.m.——WESTERN SECTION: Grand Hotel, Broad Street, Bristol, "Modern Adhesives for Industry," T. C. Ford, 7.15 p.m.

Thurs., April 19*th.*—LEICESTER SECTION: College of Art and Technology, The Newarke, Leicester, Film Show, "The Hone Abrading Process," and "The Generation of Metallic Bearing Surfaces," 7 p.m.—LONDON SECTION: Royal Empire Society, Northumberland Avenue, W.C.2, "High Frequency Heating in Production," K. A. Zandstra, 7 p.m.

Institution of Structural Engineers

Tues., April 17*th.*—SCOTTISH BRANCH: Ca'doro Restaurant, Glasgow, Annual General Meeting, 6 p.m.

Wed., April 18*th.*—YORKSHIRE BRANCH: Great Northern Hotel, Leeds, "Report on Prestressed Concrete," R. H. Evans, 6.30 p.m.

Institution of Works Managers

To-day, April 13*th.*—MANCHESTER BRANCH: Grand Hotel, Manchester, Annual General Meeting, 7 p.m.

To-day, to Sun., April 13*th to* 15*th.*—Prince of Wales Hotel, Southport, National Conference, "Works Managers and the Present Economic Situation."

Tues., April 17*th.*—LEICESTER BRANCH: Bell Hotel, Leicester, Annual General Meeting, 7 p.m.

Wed., April 18*th.*—W. MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Measurement of Productivity," W. C. Puckey, 7 p.m.

Junior Institution of Engineers

To-day, April 13*th.*—39, Victoria Street, London, S.W.1, "The Use of Models in Industry, Education, Invention and Recreation," R. H. Fuller, 6.30 p.m.

Fri., April 20*th.*—39, Victoria Street, London, S.W.1, "Aluminium as an Engineering Material," E. G. West, 6.30 p.m.——SHEFFIELD AND DISTRICT SECTION: Grand Hotel, Sheffield, "The Science and Practice of Dust Collection as Applied to Industry," G. F. H. Peacock, 7.30 p.m.

Liverpool Engineering Society

Wed., April 18*th.*—24, Dale Street, Liverpool, Annual General Meeting, 6 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, April 13*th.*—Neville Hall, Westgate Road, Newcastle upon Tyne, "The Improvement of Environmental Conditions in Ships' Machinery Spaces," Margaret Fishenden and S. A. M. Davidson, 6.15 p.m.

Old Centralians

To-day, April 13*th.*—Chez Auguste Restaurant, Frith Street, W.1, "The Future of Television—Here and Overseas," C. I. Orr-Ewing, 12.55 p.m.

Royal Society of Arts

Wed., April 18*th.*—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, "The Electricity Supply Position," Sir John Hacking, 2.30 p.m.

Society of Chemical Industry

Thurs., April 19*th.*—Institution of Structural Engineers, 11, Upper Belgrave Street, S.W.1, "Problems Involved in Obtaining Colour and Texture in Concrete Surfaces," J. G. Wilson, 6 p.m.

Stephenson Locomotive Society

Sat., April 14*th.*—N.W. BRANCH: Central Station Offices, Liverpool, "Footplate Experiences," O. S. Nock, 7 p.m.

Codes of Practice

*The Council for Codes of Practice for Buildings—Construction and Engineering Services, is under the ægis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.*1.

SPRINKLER SYSTEMS

The Council for Codes of Practice for Buildings has now issued for comment Code 402.201, "Sprinkler Systems," prepared for the Council by a Committee convened by the Institution of Mechanical Engineers.

The code deals with the general principles for the provision of automatic sprinkler installations in buildings. In addition to indicating the need to exchange certain information and to compile a time schedule for the installation of the system, the code lists the requirements for the various fittings and components and refers to the British Standards where relevant.

The design section includes general information on the installation of the three types of systems—the wet-pipe, alternate wet-and-dry pipe, and dry-pipe systems. There are recommendations regarding the number, position and operating temperatures of sprinkler heads, the operation of alarms, special precautions for systems liable to freezing, pressure gauges, valves and supply connections, piping, multiple-jet sprinklers and water supplies. There are also recommendations on systems suitable for dealing with oil fires. Information is given on the actual work of installing the system and on the regular tests necessary, including weekly and quarterly inspections.

The section of the code dealing with maintenance contains recommendations regarding the closing down and operation of the system after a fire, and the maintenance of valves, sprinkler heads, gauges, piping and fittings, hangers, alarms, tanks, and so on. There are notes on the number of spare sprinkler heads to be stocked, on avoiding the obstruction of heads, and on changes in temperature and fire risk. The code is in draft form and is subject to amendment in the light of comments, which should be submitted by May 7, 1951.